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contents

	Page
Another Year of Plenty. Continued Expansion in the Nitrogen Industry in 1958/59	1
The Chilean Nitrate Industry	8
Supply, Prices, Trends	14
Expanding Activities of W. R. Grace & Co.	18
Sahu Chemicals' Ammonium Chloride Plant on Stream	20
Ravenna. Fertilizers in a Petrochemical Complex	22
The Sumitomo Chemical Company. Expansion and Diversification	26
Ammonium Nitrate Process and Plant by the Société Belge de l'Azote	28
From Azote to Onazote. The Manufacture of Expanded Ebonite and its Use as a Thermal and Humidity Insulator	32
Use of Waste Slurry in Lime Ammonium Nitrate	37

PLANT AND EQUIPMENT

	Page
The Lindberg "Hyni" Generator	38
Ammonia Liquor Concentration Plant for the Scottish Gas Board	40

CURRENT EVENTS

		Page
Algeria	Nitrogen Production Foreseen	41
	Nitrogen from Solar Radiation	41
Bulgaria	Second Nitrogen Fertilizer Works Planned	42
Central America	Panama and El Salvador Projects	42
Formosa	Law Suit over Nankong Urea Works	43
France	Urea-Formaldehyde Fertilizer	43
India	Work Starts on Neyveli Urea Project	43
Malaya	Fertilizer Project	44
Spain	Credits for New Plants	44
Statistical Appendix		45
Index to Advertisers		xiv

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GERMANY

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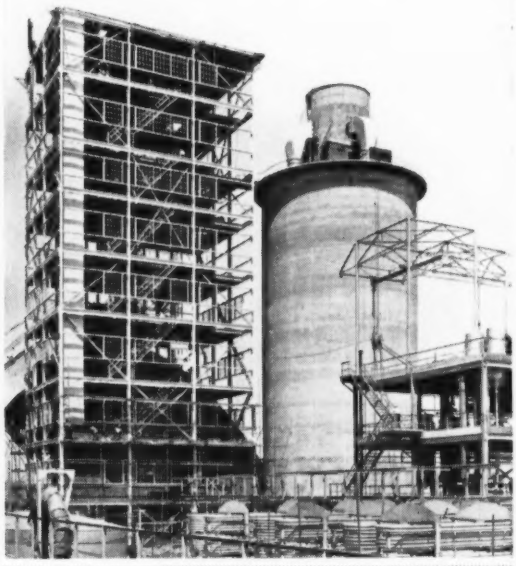
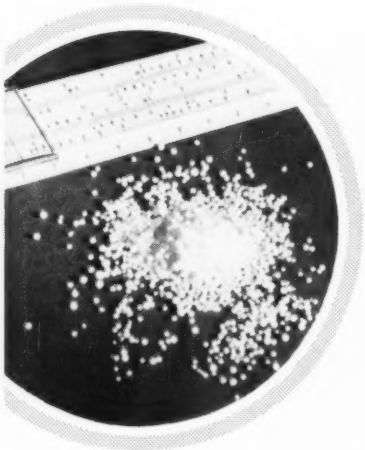
Urea plant at Modderfontein, South Africa, during erecting



300 tons of Urea per day



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Another year of plenty

Continued Expansion of the Nitrogen Industry in 1958/59

CONTINUED EXPANSION, both in production and consumption of nitrogen, was a feature of the year ending 30th June 1959. At the same time the gap between production and consumption widened by 185,000 tonnes of nitrogen. Production rose by 8¼% to 10,975,000 tonnes N, while consumption rose by 6½% to 10,498,000 tonnes N. This trend was most marked in the case of fertilizer nitrogen with production rising by 9% to 9,416,000 tonnes N, while consumption increased by 7¼% to 9 million tonnes N. There was considerable anxiety at the start of the year caused by over-supply and rising stocks, but progressive expansion of demand has narrowed the gap between supply and demand. Supplies of nitrogen for industrial use, however, rose by only 6% to 1.7 million tonnes N. Despite the evident pressure of supplies on world markets in the previous fertilizer year, world synthetic ammonia capacity increased by over 850,000 tonnes to a level of 12.3 million tonnes N during 1958-59, and in many countries the expansion of plant capacity was primarily responsible for rising production and, as a corollary, employment of existing plant capacity was in many cases cut back to a lower level.

Of the fertilizer materials, the most striking progress was made by urea—production and consumption rising by 23½% and 31½% to 667,000 tonnes N and 687,000 tonnes N respectively. Except in Japan, where stocks rose significantly, strong demand caused stocks of all other major producers to decline. World urea capacity was increased by some 580,000 tonnes (262,000 tonnes N), of which Japan alone accounted for nearly one-half. In terms of absolute quantity the most important advance was made by ammonium sulphate. World output rose by 8½% to 2,973,000 tonnes N and in the same period consumption increased 7¼% to 2,744,000 tonnes N. The greatest contribution to increased supplies came from Western Europe where production rose by 13% to 1,141,000 tonnes N. Fertilizer use of anhydrous and aqua ammonia continued to expand, rising by some 40,000 tonnes N to 635,000 tonnes N, but its use was still confined largely to the United States.

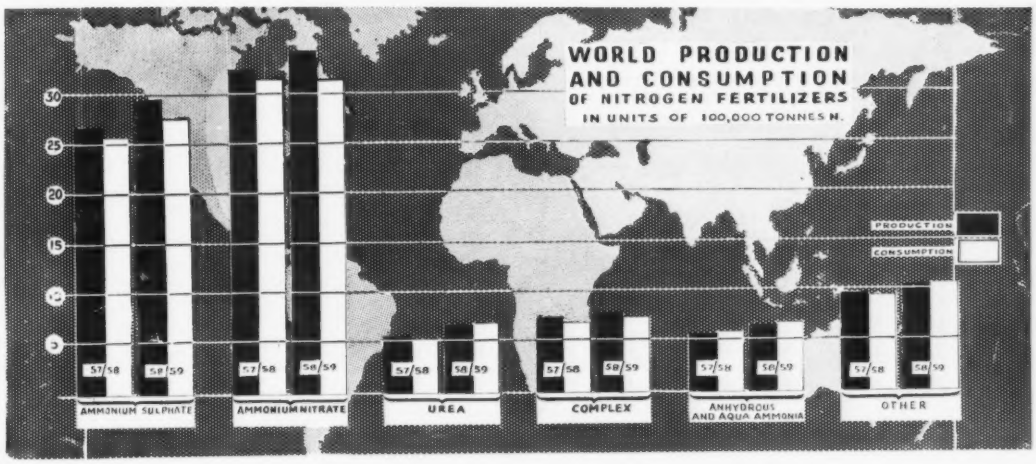


Fig. 1. World Production and Consumption of Nitrogenous Fertilizers.

In contrast to all other major nitrogen fertilizer materials, consumption of ammonium nitrate made relatively little progress, and the overall total was 3,131,000 tonnes N compared with 3,109,000 tonnes N in the previous year. Nevertheless, world production continued to expand and at 3,416,000 tonnes N was 5¼% up on the total for 1957-58. The bulk of the increased output originated from Eastern Europe, the U.S.S.R., China and North Korea. In North America both supply and demand fell slightly and there was an overall reduction in stocks.

The use of complex fertilizers made steady if unspectacular progress, while on a smaller scale calcium nitrate and calcium cyanamide continued to advance. Production of calcium nitrate, largely confined to Western Europe, increased to 4½% and 5¼% to 385,000 tonnes N and 381,000 tonnes N respectively. Calcium cyanamide supplies, remaining closely aligned to demand, rose by 8½% to 348,000 tonnes N. The position affecting sodium nitrate showed no significant change although Chilean output rose by some 9%.

WESTERN EUROPE

The most important contribution to the additional supplies of fertilizer nitrogen came from Western Europe where production rose by 7% to 4½ million tonnes N. At the same time consumption increased by 7% to 3½ million tonnes N. Gross exports increased by some 30,000 tonnes N to 1,456,000 tonnes N, the most notable advance being made by Italy, while smaller increases were registered by Belgium and Austria. At the same time West German exports fell by 139,000 tonnes N to 430,000 tonnes N from the exceptionally high figure of the previous year. On a smaller scale, the quantity of exports from France and the United Kingdom also declined. With no increase in the volume of net exports and only a slight reduction in the volume of net imports, the widening gap between production and consumption led to an overall addition of some 100,000 tonnes N to the level of stocks. The most notable advance in output was achieved by Italy where, with the inauguration of the ammonium sulphate works of A.N.I.C. at Ravenna, production rose by 28% to 542,000 tonnes with a consequent expansion of this country's exportable surplus. Stimulated by important purchases from China, Belgian output rose sharply to 297,000 tonnes N, an increase of 15% over the total for the preceding year. Important extensions to plant were carried out by Carbochimique S.A. at Tertre and by Union Chimique Belge at Zandvoorde

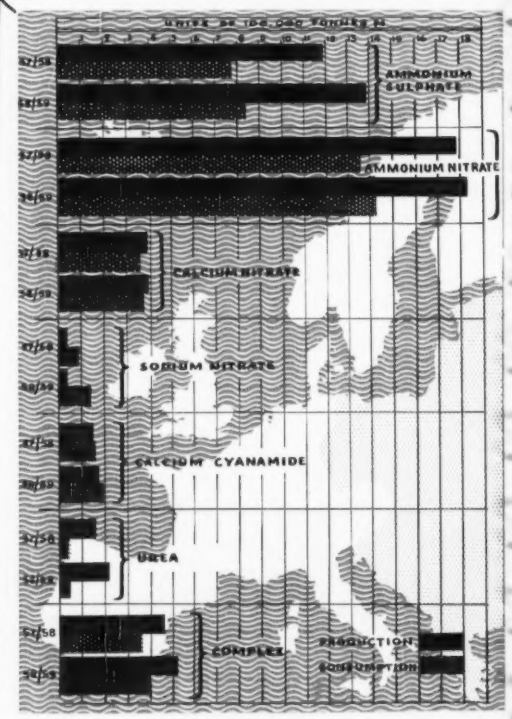


Fig. 2. Production and Consumpion of Nitrogenous Fertilizers in Western Europe.

where the work of doubling the capacity of the ammonia installations was completed at the end of 1958. In France production rose by 6% to 542,000 tonnes N against a background of improvements to plant efficiency and extensions to capacity carried out by several manufacturers. During the year the first stage in the current expansion programme at the Toulouse works of the Office National Industrial de l'Azote (O.N.I.A.) was completed, raising the ammonia capacity from 90 to 125 tonnes a day.

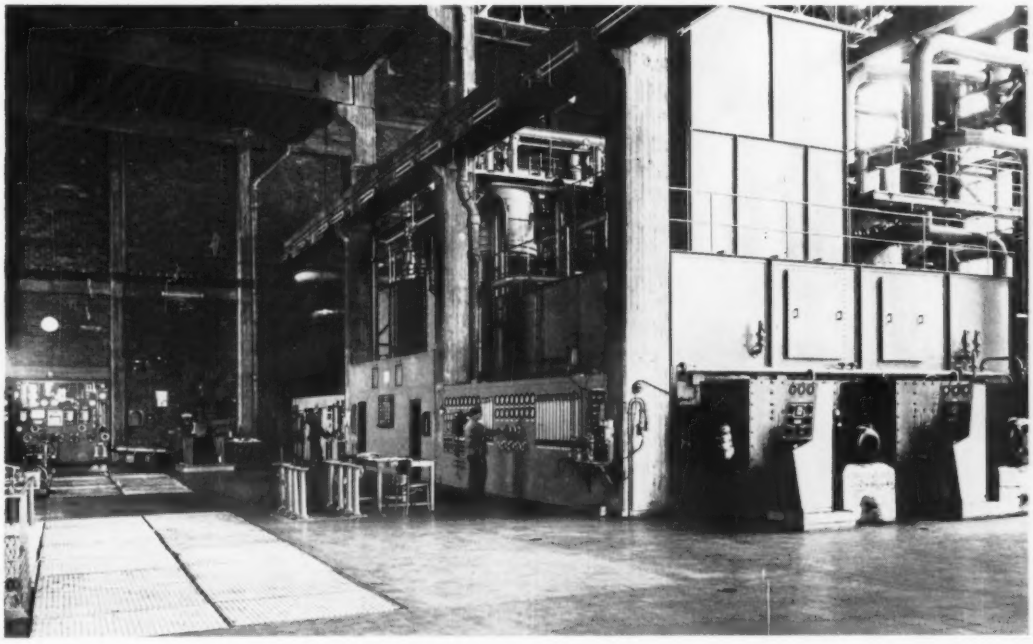
Among other major manufacturing countries there were no significant increases in production. In West Germany the level of

fertilizer nitrogen output was maintained at 1,050,000 tonnes N. Ammonium sulphate output rose from 223,000 to 233,000 tonnes N while supplies of ammonium nitrates contrated from 494,000 to 448,000 tonnes N. Stimulated by growing domestic demand, calcium cyanamide output rose from 86,000 to 101,000 tonnes N, while the two principal manufacturers have taken steps to enhance the qualities of their product.

In the United Kingdom domestic consumption of fertilizer nitrogen increased by over 7% to 335,000 tonnes N, although production remained at a level of 350,000 tonnes N. Strong domestic demand, accentuated by modest exports to the Commonwealth area, necessitated the import from the Continent of 30,000 tonnes N, mainly in the form of ammonium sulphate. At the close of the fertilizer year the 60,000-tonne per year ammonia plant built for Shell Chemicals Ltd. at Shellhaven came on stream. In the Netherlands, Norway and Austria there were no important developments in production or consumption affecting the quantity or type of nitrogen fertilizer materials, although measures were taken by several producers to rationalize and improve the efficiency of their operations.

Possibly one of the most significant developments affecting the Western Europe fertilizer nitrogen situation occurred in Portugal where domestic output rose from 18,000 tonnes N in 1957-58 to 43,000 tonnes N in 1958-59, a result of the inauguration, in July 1958, of the additional ammonium sulphate facilities at the Estarreja works of Ammoniaco Portuguese S.A.R.L. Portugal was thus able to meet two-thirds of her requirements as compared with only one-third in 1957-58. In Spain, where work on extensive additions to domestic nitrogen capacity is in progress, there was no marked increase in the level of production. Consumption, on the other hand, rose by 53,000 tonnes N to 260,000 tonnes N, additional supplies being largely in the form of imported ammonium sulphate.

During the year 1958-59 some 450,000 tonnes of additional nitrogen capacity came



Belgium. Instrumentation section of the Linde and Casale units at the Zandvoorde works of Union Chimique Belge.

on stream on Western Europe and overall employment of capacity fell therefore from just over to just under 90%, a level which remains appreciably higher than that pertaining in other major producing areas.

EASTERN EUROPE

Remaining essentially a self-sufficient entity in respect of nitrogen supplies, Eastern European countries further reduced their already modest level of imports from the rest of the world during the year under review, while the volume of their exports has yet to make any significant impact on international trade. Production of nitrogen in all forms rose by 13½% to 1,605,000 tonnes N while consumption increased by 11¼% to 1,620,000 tonnes N. Of this it is estimated that technical nitrogen accounted for some 94,000 tonnes N. The bulk of supplies continued to originate from the U.S.S.R. and Eastern Germany, the latter exporting her surplus production principally to other countries in the Communist bloc. In the U.S.S.R. production is estimated to have risen by 50,000 tonnes to 800,000 tonnes N with consumption, stimulated by additional supplies from East Germany, increasing at a slightly faster rate to a level of 830,000 tonnes N. Of this some 80,000 tonnes N were used for industrial purposes. Over one-half of total nitrogen supplies in the U.S.S.R. continued to be in the form of ammonium nitrates and there was no appreciable development of the manufacture of urea and complex fertilizers. East German production increased by 4½% to 320,000 tonnes, the most important advance being made by ammonium nitrates. Ammonium sulphate nevertheless continues to account for more than one-half of total output. None of the increased production in East Germany can yet be attributed to extensions and modernization being carried out at the VEB Leuna-Werke Walter Ulbricht or the smaller Stickstoffwerk Piesteritz. The effect of these operations, should, however, be felt by 1961 when total output is expected to rise by at least 25% and when ammonium nitrates and urea should be available in substantially greater quantities.

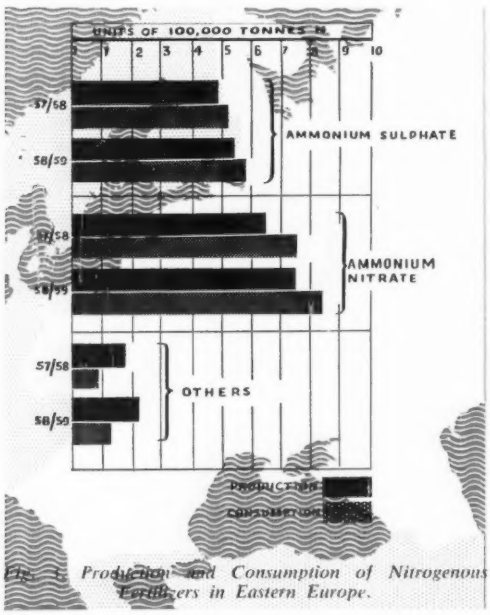


Fig. 5. Production and Consumption of Nitrogenous Fertilizers in Eastern Europe.

Other countries in Eastern Europe to show important increases in nitrogen production during 1958-59 were Poland, Czechoslovakia and Hungary. In Poland, where extensions to the important Kedzierzyn works in Silesia were brought into operation in July 1958, production of fertilizer nitrogen rose from 208,000 to 250,000 tonnes N, virtually all the additional output being made available for export principally to the U.S.S.R. In Czechoslovakia fertilizer nitrogen production rose from 82,000 to 133,000 tonnes N, although in this case the additional supplies were absorbed by domestic demand. Hungary, largely in the process of economic recovery from the effects of the political disturbances of 1956, more than doubled her nitrogen production to 44,000 tonnes N, although additional supplies were still required from Poland, East Germany and the U.S.S.R.

NEAR EAST AND MIDDLE EAST

There were no important developments in the nitrogen fertilizer situation in the Near East in 1958-59. Consumption in this area increased from 44,000 to 48,000 tonnes N, but production remained at a level of 15,000 tonnes N—confined to output from the Haifa works of Fertilizers & Chemicals Ltd. and to small

quantities of by-product material in Turkey. The first important addition to capacity in the Near East will be the Kutahya works in Turkey due to come into operation in the summer of this year, and will be followed by fertilizer plant at Homs in the Syrian region of the United Arab Republic and at Shiraz in Iran. The Homs and Shiraz plants are, however, a long way from completion. Production at these three new plants, with a combined capacity of 95,000 tonnes N, is to be in the form of ammonium nitrate and lime ammonium nitrate, with ammonium sulphate also being manufactured at Kutahya. It is not, however, known whether any of the ammonium nitrate is to be used in nitrogen solutions, a practice which was developed on a small scale in Israel in the year under review and which could find favour in neighbouring countries for use in conjunction with the irrigation projects which play such an important part in their agriculture.

AFRICA

There were no major developments in 1958-59 affecting the overall pattern of nitrogen supplies in the African continent. Production rose by 10,000 tonnes N to 87,000 tonnes N, the bulk of the additional material being ammonium nitrate supplies for use as industrial explosive from the Modderfontein works of African Explosives & Chemical Industries Ltd. No increase in production or consumption was reported from the Egyptian region of the United Arab Republic, the former totalling 32,000 tonnes N and the latter 155,000 tonnes N. Overall consumption of nitrogen in Africa rose by 6½% to 280,000 tonnes N of which 242,000 tonnes N were in the form of fertilizer materials.

INDIAN SUB-CONTINENT

Both production and consumption of nitrogen continued to increase in the Indian sub-continent during 1958-59, production rising from 85,000 to 102,000 tonnes N and consumption from 190,000 to 210,000 tonnes N. Nevertheless, this level of consumption and imports —in respect of which India is enhancing her position as one of the world's leading markets —failed to reach the level set down by the Second Five-Year Plan. The bulk of the additional domestic supplies originated from the Sindri works in Bihar State, where capacity has been raised from 70,000 to 117,000 tonnes N. India has also accounted for virtually all the additional consumption and a notable feature in this country was the gain made by ammonium sulphate at the expense of ammonium nitrates, the former advancing by 39,000 tonnes N to 138,000 tonnes N, while the latter fell to 9,000 tonnes N from 24,000 tonnes N used in the preceding fertilizer year.

SOUTH-EAST ASIA AND THE FAR EAST

The overall returns for South-East Asia for the year 1958-59 show substantial growth in both production and consumption of nitrogen. The former rose by 19% to 1,397,000 tonnes N and the latter by 10% to 1,635,000 tonnes N. Japan, by far the most important producer in South-East Asia and the Far East, increased the level of her fertilizer nitrogen output by 11% to 989,000 tonnes N, urea supplies rising from 176,000 to 251,000 tonnes N and ammonium sulphate supplies rising from 530,000 to 577,000 tonnes N. Despite this and

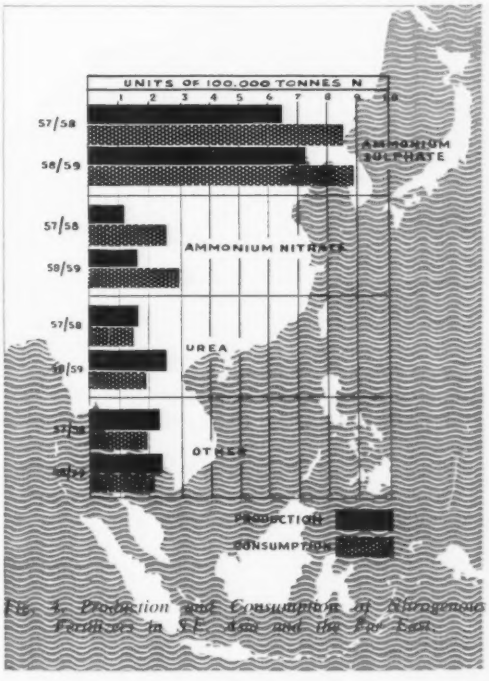


Fig. 3. Production and Consumption of Nitrogenous Fertilizers in S.E. Asia and the Far East.

an extensive export drive, stocks mounted and are estimated to have approached 200,000 tonnes N by June 1959. Nevertheless, towards the end of the year under review it was evident that rationalization measures recommended for the Japanese fertilizer industry were beginning to take effect, for there was a noticeable contraction in calcium cyanamide output as a result of the closure of an old works and consideration was being given to close also several of the older and less efficient ammonium sulphate plants. At the same time, the bulk of the additional ammonia capacity coming on stream during the year was used for the manufacture of urea. These measures are primarily intended to enable the Japanese nitrogen industry to improve its ability to sell in export markets in the face of severe and growing competition.

China, next to Japan the most important manufacturer in this area, raised her output of fertilizer nitrogen by 50% to 240,000 tonnes N, the greater part of which was in the form of ammonium sulphate and ammonium nitrates. Her domestic market, however, the principal outlet for West European exports, expanded by only 11% to 500,000 tonnes N, with imports of ammonium nitrates advancing at the expense of ammonium sulphate. The level of imports remained constant at about one-quarter million tonnes N. In South Korea, where I.C.A. shipments continued to account for a large proportion of imports, there was no significant change in the level of demand which remained at a level of 150,000 tonnes N. By contrast, production and consumption in North Korea rose by about 50%, their present level exceeding 80,000 tonnes N.

The overall growth of nitrogen capacity in South-East Asia and the Far East during 1958-59—some 250,000 tonnes N—coupled with the intensity of Japanese nitrogen sales in this area, caused a contraction of imports from the rest of the world, reducing their level by one-fifth. This trend may become more pronounced when additional capacity now under construction in these countries and in South Korea is brought into operation within the next two years.

NORTH AMERICA

Despite a further substantial increase—some 500,000 tonnes N—in capacity during 1958-59, production in the United States and Canada rose by only 82,000 tonnes to 3,336,000 tonnes N. The only major nitrogen plant to be withdrawn from service was the 100,000-tonne per year works at Morgantown, West Virginia. The operators, the Olin Mathieson Chemical Corporation, maintain that this plant, which used water gas, had become uneconomical to run. Nevertheless, with overall employment of capacity at 75%, most ammonia plants were operating well above the minimum level of employment at which they can economically operate.

Ammonium sulphate production fell by 7¼% to 385,000 tonnes N, largely due to a reduction in output of by-product material occasioned by the economic recession prevailing in the first half of the year. At the same time stocks of ammonium sulphate were reduced with domestic demand rising by 33,000 tonnes N. Stocks of urea were also substantially reduced due to consumption rising by more than one-quarter to 290,000 tonnes N, while production showed only a very slight increase to a level of 235,000 tonnes N. The

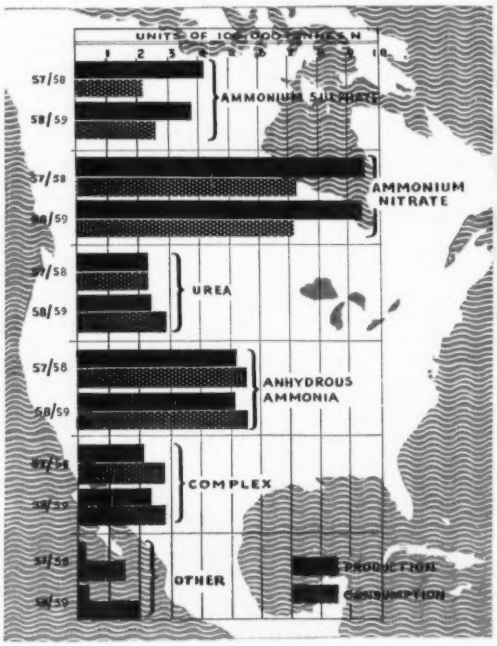


Fig. 5. Production and Consumption of Nitrogenous Fertilizers in North America.

use of anhydrous ammonia for fertilizer application continued to expand and is estimated to have attained a level of 540,000 tonnes N.

In contrast to urea, anhydrous ammonia and ammonium sulphate, the use of ammonium nitrate declined by 20,000 tonnes N to 705,000 tonnes N despite the growing demand for this material in solution form. With output falling by only 10,000 tonnes N to 945,000 tonnes N there was no significant reduction of stocks. Both from the United States as well as from Canada exports were sustained by I.C.A. requirements, mainly to the Far East.

With continuing additions to ammonia facilities, particularly in the west, there was an appreciable measure of over-capacity in the United States. This promises to be aggravated by current additions and improvements to Canadian nitrogen fertilizer installations. During the current fertilizer year the urea plant built for Cyanamid of Canada Ltd. at Hamilton, Ontario, came into full operation while work has started on the extension and conversion of their Welland works to the use of natural gas. At the same time the capacity of the ammonium sulphate recovery works of Sherritt Gordon Mines Ltd. at Fort Saskatchewan, Alberta, is to be doubled, while a new manufacturer, Brockville Chemical Ltd., is to enter the field with a 60,000 tonnes N per year works at Maitland, Ontario.

CENTRAL AND SOUTH AMERICA

In Central and South America the year 1958-59 was marked by the entry of the Cubatao calcium nitrate and ammonium nitrate works, operated by the state-owned Petroleo Brasiliero S.A. (Petrobas). A slight increase in supplies in the form of Chilean nitrate and Mexican synthetic ammonia coupled with the new Brazilian plant contributed to a 7½% growth in nitrogen production to a level of 233,000 tonnes N. At the same time overall consumption rose from 282,000 to 323,000 tonnes N, affording an expanding market for imports from North America and Western Europe.

TECHNICAL NITROGEN

The increase in world demand for nitrogen for industrial purposes continued to lag behind that of fertilizer nitrogen, rising by 6% to 1.7 million tonnes N during 1958-59. Virtually all the additional use was confined to Europe, Japan and South Africa with no appreciable increase in consumption in North America. In some respects this result fell below expectations, particularly in the case of urea where demand for important applications in the manufacture of plastics has repeatedly failed to develop at the rate which has been previously forecast.

SUMMARY AND OUTLOOK

Despite the significant, if slower, rate at which new capacity came into operation during the year, the supply position remained in equilibrium, except in Japan where the Ammonium Sulphate Export Corporation was forced to come to the assistance of producers by guaranteeing to buy the entire tonnage allocated to export. In many countries, particularly where older plant had previously been working close to or even at a level exceeding its rated capacity, the intensity of operations during the year under review was substantially lowered. Modernization and rationalization programmes started often involving conversion to the use of more commercially viable raw materials such as fuel oil and natural gas, notably in West Germany, the United Kingdom and Holland.

It is anticipated that in 1959-60 both world production and consumption of fertilizer nitrogen will rise by at least 7% and that industrial nitrogen use will exceed 1½ million tonnes N. In Western Europe, North America and Japan the trend of restricting output to lessen the gap between supply and demand is likely to continue, with production and consumption maintaining their advance. While the overall growth of capacity in these established producing areas is being substantially slowed down in the principal importing areas it continues to accelerate and by the end of the current year the world surplus nitrogen capacity will in fact have expanded.

Chilean Nitrate Industry

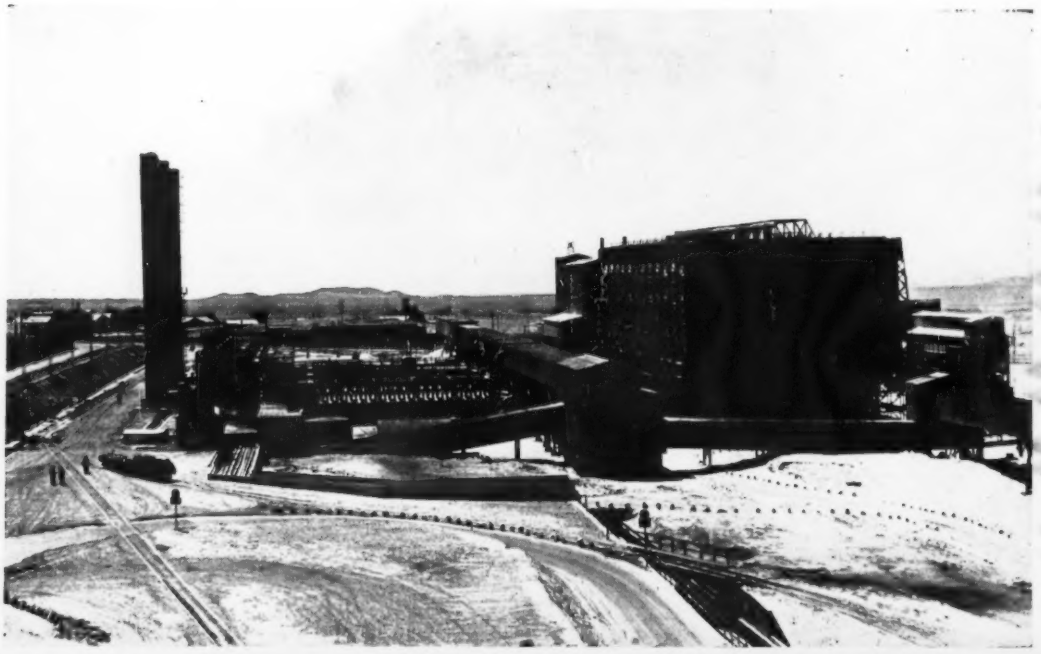
CHILE HAS BEEN exporting natural nitrate of soda since 1830 and has played a continuous rôle in the nitrogen commerce of the world longer than any other nitrogen producer. This rôle was predominant in the nineteenth century and it so continued up to the outbreak of World War I. For a period of 50 years, from 1850 to 1900, Chilean nitrate accounted for 70 per cent of the world consumption of nitrogenous fertilizers and it satisfied more than half the total demand for nitrogen thereafter up to 1914.

The shipment of nitrate from Chile began in a modest way with a cargo of 813 tons in 1830 followed by average annual exports of 3,000 tonnes which did not grow beyond 7,000 tonnes per annum in the first decade of trade, ending in 1840. Then came a tremendous rise in the demand for nitrogenous fertilizers—which meant principally Chilean nitrate of soda—after Baron Justus von Liebig, the German chemist, propounded in 1840 his theory that the soil must be fertilized intensively to produce larger crops. The Chilean producers increased their output of natural nitrate steadily to meet the expanding demand and by the turn of the century they were exporting nearly 1,500,000 tonnes of nitrate per annum.

Other sources of commercial nitrogen remained confined largely to ammonium sulphate obtained as a by-product from coke ovens and Chile was still supplying about 65 per cent of the nitrogen requirements of the world in the opening years of the twentieth century. This dependence on virtually a single source of supply for nitrogenous fertilizers began to raise apprehensions as the use of commercial nitrogen for agricultural purposes became more and more common. How big was the supply? What would happen if it failed? As far back as 1898 Sir William Crookes, the English chemist and physicist, gathered information which indicated that the nitrate beds in Chile would not last longer than another 20 or 30 years—50 years at the most. According to these estimates the Chilean deposits of nitrate-bearing ore would be exhausted by about 1930 and even if their life could be prolonged by working lower grade ores they could not be expected to last beyond, say, 1950.

Basing himself on the growing wheat

General view of a Nitrate Plant.



needs of the world in relation to the quantities of Chilean nitrate required to produce larger wheat crops, Sir William Crookes drew alarming conclusions about the future food supply of Western mankind. "England and all civilized nations," he said, "stand in deadly peril of not having enough to eat."

As the reserves of nitrate-bearing ores in Chile had not been exhausted by 1930, nor by 1950, and in fact improved methods of elaboration assure their further life for generations still to come, the words of Sir William Crookes are sometimes quoted out of the context of the presidential address in which he delivered them to the British Association for the Advancement of Science in 1898, to illustrate the foolhardiness of attempting to predict the future. In fact, he was pleading for the development of a synthetic nitrogen industry. "The fixation of nitrogen," he said, "is a question of the not far distant future. Unless we can class it among certainties to come, the great Caucasian race will cease to be foremost in the world, and will be squeezed out of existence by races to whom wheaten bread is not the staff of life."

The atmospheric nitrogen industry was not long delayed in coming into existence. Made economically feasible by German chemists and strategically indispensable to the Central Powers by the Royal Naval blockade of World War I, the industry flourished very rapidly. Production of synthetic nitrogen (other than coke-oven ammonium sulphate), which had been 8,000 tons of N or 1.4 per cent of the total N output in 1910 and expanded to 70,000 tons or about 10 per cent of the total in 1914, became 205,000 tons in 1915 and in 1918, the last year of the war, it rose to 416,000 tons N or nearly 35 per cent of the world output of N. The share of Chilean nitrate in the world nitrogen market had declined by the close of World War I to about 33 per cent of the total.

Rise of Competition

To-day Chilean participation in the fertilizer nitrogen business does not greatly exceed two per cent. This decline in percentage is the inevitable outcome of the enormous rise in the demand for nitrogen in recent years. World production and consumption of fertilizer nitrogen have expanded more than three and a half times in the last 20 years, since the outbreak of World War II. The total production in

Caliche being loaded into rail wagons for taking to the crushing machines.

1938/39 was 2,678,000 tonnes of N. For the past year 1958/59 the total is estimated at 9,580,000 tonnes.

The Chilean share of the fertilizer nitrogen industry over a period of years is shown in the following table :—

FERTILIZER NITROGEN PRODUCTION

(000 tonnes N)

	1928/29	*1938/39*	*1948/49*	*1958/59*
World ...	1,911	2,678	3,559	9,416
Chile	525	228	280	202
Chile % of total	27	9	8	2

The rise of the synthetic nitrogen industry has confronted Chile with the problem of meeting keen competition. Synthetic producers have often enjoyed important advantages over Chile, such as government subsidy; a substantial home market protected by import restrictions, the diversification of risks over a wide range of chemical products, and low transport costs to export markets frequently in close proximity to the point of production. The Chilean industry, on the other hand, has been dependent almost entirely on export markets which lie for the most part at great distances and involve relatively heavy transport charges. Instead of drawing on public funds it contributes to the Chilean national income by sharing profits with the government. The risks of the industry are concentrated in one product—nitrate—and in one important by-product, iodine.

Chile has met synthetic competition by improving the presentation of the product and by modernizing and streamlining its production methods to reduce costs, a process which has been continuous for the last 35 years.

Exceptional Environment

From the point of view of economic operation, a major handicap of the industry, and one which no amount of engineering ingenuity can entirely overcome, is its geographical position in a remote rainless barren desert to which water, fuel, food and all other supplies for plant and personnel must be transported from a long distance.

Chilean nitrate is extracted from ores found in a desert plateau 3,000 feet above sea level, which interrupts the rise of the coast land of northern Chile from the Pacific Ocean to the Andes Mountains. The plateau is 500 miles long and nearly 100 miles wide. In this desert the nitrate fields, unique in the world, are concentrated in a strip of land 300 miles long and varying in width from 12 to 20 miles.

After the caliche is crushed to 1.5 cm. it is taken by conveyor belt to the loading machine which discharges it into the extraction tank below.

The nitrate beds are irregular in their formation and they are not continuous, being separated by large tracts of barren ground which contain no nitrate ore.

The evolution of the Chilean nitrate industry has been conditioned by its exceptional physical environment. In these surroundings many thousands of people live and work, for the nitrate is lixiviated out of its ore and elaborated to the finished product on the desert before being transported to one of the ports for shipment. The nitrate ore occurs in layers about one to three feet below the surface of the ground and its removal is a form of open-cast mining. The older system of production, known as the Shanks process, was based essentially on hand mining and sorting. It required high-grade ores containing at least 13 per cent sodium nitrate and the recovery of the nitrate content of the ores did not exceed 65 to 70 per cent.

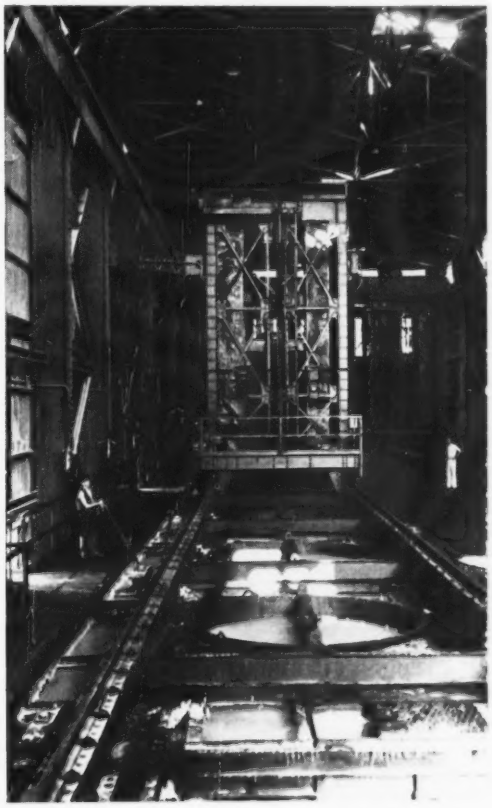
Guggenheim Process

This old system has been superseded and to-day the bulk of the nitrate is produced by the Guggenheim process which is highly mechanized and can treat low grade ores containing as little as 8 per cent sodium nitrate. The recovery rate by this process is 85 to 90 per cent.

The ore, known as caliche, is mined by power shovels which load it into electric trains for transport to the extraction plant. The most important feature of the Guggenheim process is the method of leaching and crystallization. The caliche, after being crushed, is dissolved in a series of tanks containing graduated strengths of mother liquor circulating at about 40°C. The mother liquor is cooled in two stages in a series of crystallization tanks, the final temperature being 5°C. Cooling of the mother liquor crystallizes the sodium nitrate and leaves practically all other salts in solution. There is a great economy in the method of crystallization, for the heat required to raise the temperature of the mother liquor in the dissolving stages is recovered in part by heat interchangers connected with the ammonia condensers which cool the crystallization tanks and in part from the exhaust gases and cooling water from the diesel engines which are used to generate electricity. In all, about 80 per cent of the total heat content of the fuel oil is recovered either as electrical energy or as heat for the leach solutions.

The nitrate is dried in centrifugal tanks and then passes to the final process of granulation. This consists in melting the centrifuged nitrate in oil-fired furnaces and spraying the melt at 340°C into a large chamber. The liquid droplets, in their passage through the air, cool below the freezing point and are collected as

small pearl-like pellets on a belt conveyor underneath the spray chamber, which passes them to coolers and finally to a storage bin for bagging or bulk shipment.



The Crystallization Chamber. After leaving the extraction tanks the warm nitrate solution is circulated through a series of circular tanks, each consisting of 600 tubes. After crystallization a battery of iron rods forces out the nitrate.

Anglo-Lautaro Enterprise

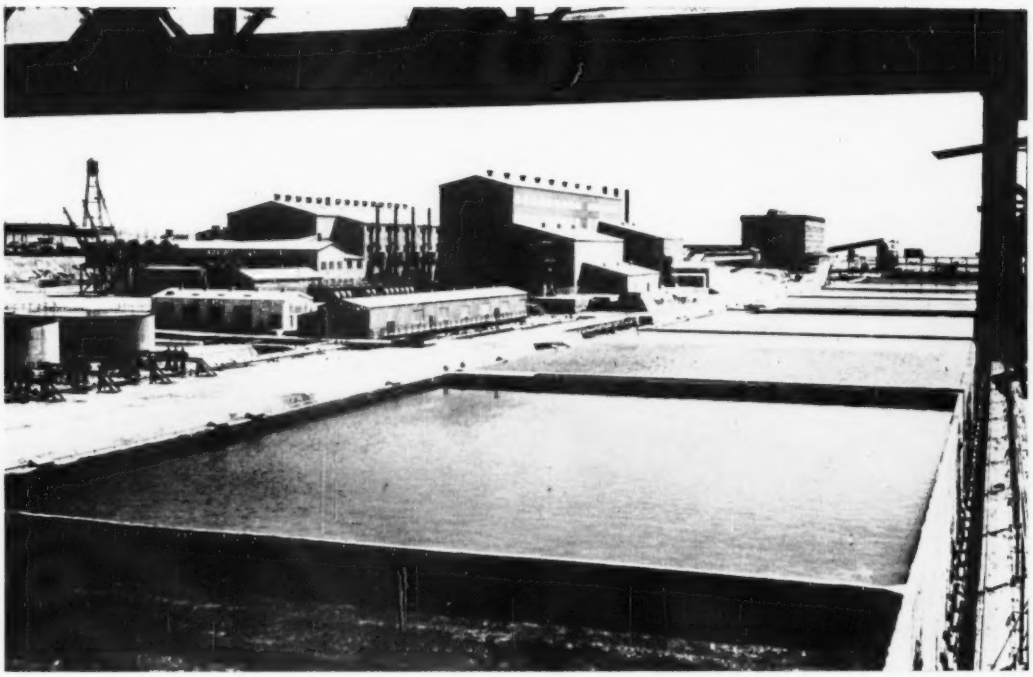
The Shanks plants or oficinas had a capacity varying from 10,000 to 110,000 tons for each installation and there were about 150 of them in 1926 when the Guggenheim process was first introduced into the industry. The Guggenheim method is used at two large plants known as Maria Elena and Pedro de Valdivia, capable of producing 1,200,000 tons of nitrate annually. These two plants are operated by the Anglo-Lautaro Nitrate Corporation which accounts for about 70 per cent of nitrate sales and is owned by American and British capital under the control of the Guggenheim family of New York. The modernization of the Chilean nitrate industry has been due up to now in a very large measure to the enterprise and financial resources of this banking family which has invested upwards of $115,000,000 in the industry in the past 35 years.

A further step taken by the Anglo-Lautaro Nitrate Corporation to increase the output and efficiency of its plants is the solar evaporation project which is designed to complement the Guggenheim process and makes it possible to recover potash nitrate, additional sodium nitrate and iodine and other chemical by-products, such as sodium sulphate, boric acid and magnesium salts, from liquor heretofore discharged to waste in the plant tailings. The solar evaporation process should greatly extend the life of the nitrate fields as it can be applied to nitrate minerals down to 4.5 per cent grade or even lower.

With the aid of loans of $25,000,000 from the U.S. Export/Import Bank and other sources the Anglo-Lautaro Nitrate Corporation has been investing further large sums in various improvements including the enlargement of the solar evaporation plant. The same Bank has advanced nearly $12,000,000 to the Tarapaca and Antofagasta Nitrate Company for plant modernization which will assist in reinforcing the competitive strength of the industry.

Organization

The sale of nitrate and iodine is a monopoly of the Chilean Nitrate and Iodine Sales Corporation, of Santiago, which was created by law in 1933 with a life of 35 years. The monopoly will therefore be operative in its present form for eight more years. The Board of the Corporation consists of five Fiscal Directors and five Industrial Directors and a President who by law must be Chilean. Forty per cent of the profits go to the Chilean Government and the balance is allocated to the producers. The producers are mainly two large companies, the Anglo-Lautaro Nitrate Corporation and the Tarapaca and Antofagasta Nitrate Company, which together represent nearly 90 per cent of the business. The remaining 10 per cent of the industry is in the hands of small producers.



General view of a Nitrate Plant showing extraction tanks.

Characteristics as Fertilizer

Chilean nitrate of soda contains 16 per cent nitrate nitrogen, 26 per cent sodium and about 30 trace elements, principally boron and iodine. Its chief use is as a fertilizer, though it is employed also in the manufacture of glass, chemicals and explosives. The agricultural claims made for it are that it supplies nitrogen wholly in the nitric form directly assimilable by crops; that it supplies sodium which takes the place of potassium under certain conditions; that it reduces soil acidity; that it supplies trace elements; maintains the ionic balance of the soil and is available to plants in dry weather. It is used on all crops and is especially effective on the sodium-loving plants such as beet and cotton.

Worldwide Market

The market for Chilean nitrate is worldwide but the chief importer is the U.S.A. which consumes between 500,000 and 600,000 tonnes annually—more than a third of the output of the industry—notwithstanding its own large production of fertilizer nitrogen, now well in excess of 2,000,000 tonnes N per annum. In fact, many of the countries which import Chilean nitrate for agricultural purposes year after year are themselves important nitrogen producers—for example: Great Britain, France, Belgium, Holland, West Germany—to mention only a few.

Iodine

While the development of the solar evaporation process is expected to extend the range of by-products of the industry, the only substantial by-product derived up to the present time from the elaboration of Chilean nitrate is iodine. This is precipitated in elemental crystalline form from mother liquors spent after the extraction of nitrate.

Throughout its history the Chilean nitrate industry has been a dominant factor in world iodine trade and holds the leading place as manufacturer and exporter of this commodity. Until Chile exported iodine for the first time in 1868, world needs were supplied entirely by chemical industry based on seaweed. The

Loading nitrate at the Port of Iquique by conveyor belt.

half-century, 1870-1920, saw the gradual decline and virtual eclipse of the seaweed iodine industry in face of rising and cheaper Chilean production.

The high price of iodine, stable for nearly 13 years 1919-1932, stimulated competitive new production from brines and underground waters in California and Japan by methods of extraction more economical than those used for seaweed.

To-day world consumption, excluding the U.S.S.R., approaches 2,400 tonnes and is shared by Chile with the U.S.A. and Japan. Chile retains her dominant position in the iodine trade as supplier of 59 per cent of the total.

WORLD CONSUMPTION OF IODINE BY SOURCE OF PRODUCTION

(Tonnes)

10-year periods	*Caliche*	*Waters*	*Seaweed*	*Total*
1909/10 - 1918/19	620	—	214	834
1919/20 - 1928/29	574	39	170	783
1929/30 - 1938/39	517	183	194	894
1939/40 - 1948/49	947	300	72	1,319
1949/50 - 1958/59	939	681	7	1,627

The Future

What of the future of Chilean nitrate? Synthetic nitrogenous fertilizers multiply in numbers and variety as the world demand for nitrogen continues to increase, and yet it is significant that the U.S.A., the world's largest synthetic nitrogen producer, remains the world's largest consumer of Chilean nitrate and that other N producing countries, despite the fact that they have a surplus of synthetic N production, still import nitrate from distant Chile. Evidently Chilean nitrate supplies a special need for which no substitute exists. One of its attractions is its quick action which gives the farmer or market gardener a rapid return on his outlay. At any rate, there is a favourable augury for the future of the industry in the fact that it disposes of its entire output to-day with greater speed and ease than it did before the war when synthetic competition was only a fraction of its present importance.

We are indebted to the Nitrate Corporation of Chile Limited for placing this article and illustrations at our disposal.

Supply · Prices · Trends

WORLD SUPPLIES OF NITROGEN which, in the year ending 30th June, 1959, advanced 8¼% continued to expand at a rate estimated to be no smaller. At the same time demand has proved commensurate to this level of supplies and since the late autumn of 1959 there has not been an apparent surplus nor a measurable increase in overall stocks. The main strength of expansion of Nitrogen use has been confined to fertilizers and although a number of industrial uses have shown significant advances, such as the use of gaseous nitrogen, some industrial applications of nitric acid and the use of urea in plastics manufacture, the aggregate growth of industrial nitrogen consumption is less than 4% per annum compared with double this rate in the case of fertilizer nitrogen.

The effect on markets has been a notable scarcity of spot supplies and satisfactory order books not only in respect of domestic markets but also of exports which has favourably affected the outlook of most major producers, especially those in Western Europe.

The reaction on prices has been less pronounced than the overt supply situation might warrant. Domestic prices generally are lower this fertilizer year than last. In export markets there has been an advance of about 8-10% in publicised prices but in the highly competitive markets and on several tender offerings the advance in price levels is not significant. One of the effects of the tighter supply situation, is a similarity of publicised prices. A notable development has been the closer exchange of views between the majority of Europe's major nitrogen producers. The levels of production are carefully governed to avoid excessive volumes of nitrogen fertilizer forcing themselves on the market and the few indications last year of offers and sales in another major producer's home market, do not now appear to occur.

Critical factors in the world supply picture during the coming months are the developments in the U.S.A., Japan and China. In the U.S.A. the size of domestic demand which is influenced by climatic conditions determines the export surplus of the industry which has expanded output substantially following last year's tight supply position in urea and ammonium sulphate. Japan, holding very large fertilizer stocks, is still facing considerable difficulties in finding markets for her export surplus of ammonium sulphate and urea. China's import needs as in the past years ultimately determine the supply picture in Western Europe, notably Belgium, West Germany and Holland; although substantial shipments have already been made which are highly contributory to the present low level of saleable stocks, the bulk of anticipated deliveries to China has yet to be bought. These considerations, notwithstanding the apparent strong statistical picture to date, influence the current price level which reflects the balance between caution and confidence on the part of the major producers.

United States

The prolonged severe winter weather seriously embarrassed several major nitrogen producers, especially as it followed on a very wet autumn which restricted movement of fertilizers from warehouse to farm. Production in recent months has moved up to high levels and employment of synthetic ammonia capacity, which at the end of the year reached 5.32 million short tons, advanced to about 80%. Output for 1959 totalled 4.1 million short tons. With the resumption of work in the steel industry by-product ammonium sulphate output rose towards peak levels. Rising stocks restricted synthetic ammonium sulphate production which having risen to over 96,000 short tons in October fell back to around 90,000 short tons monthly. Ammonium nitrate stocks also rose 35,000 short tons in October alone following the high level production and this trend continued necessitating a limitation of output. Whereas production levels of solid fertilizers in the autumn of 1959 were 15% above those in the previous autumn, output of nitrogen solutions was nearly 50% higher reflecting the rapid growth of the liquid

fertilizer sector. Now numbering over 300 plants, the bulk in North Central states, liquid fertilizer represent 4-5%—about ½-million tons —of total U.S. fertilizer output.

Output of gaseous nitrogen showed an exceptional though partly misleading advance in 1959. Comparable industrial use rose about 30% to 9 billion cubic feet but in addition a new plant which started operating in April 1959 produces 4½ billion cubic feet of nitrogen which was however sold to fertilizer use.

The delayed start of the spring fertilizer season affects all major fertilizers and ammonia, ammonium sulphate, urea and ammonium nitrate unable to enter their customary domestic markets and accumulating in warehouses are temporarily pressing on to export markets; low world prices, however, raise doubts whether they will be competitive in any significant quantities.

New projects announced in recent months include a nitric acid plant based on new 25,000 t.p.a. ammonia capacity, to be built for Solar Nitrogen Chemicals at Lima, Ohio. The Tennessee Corporation plans to build a 100,000 t.p.a. ammonia plant near Tampa, Florida, to be operated by U.S. Phosphoric Products. About one-third of the output will be supplied to Southern Nitrogen Co. and the balance used in the manufacture of Di-Mon, a N-P fertilizer.

Western Europe

In the United Kingdom the level of nitrogen production has increased partly as the result of the anhydrous ammonia plant of Shell Chemical Co. at Shellhaven operating nearer its design capacity of 60,000 tons NH_3 and also due to the impact of I.C.I.'s new 60,000 t.p.a. fuel oil based installation on available ammonia supplies.

Following the acquisition from W. & H. M. Goulding and Co. of 51% of the share capital of Richardson Chemical Fertilisers and Manure Ltd. in Belfast, Northern Ireland, I.C.I. is reported to plan installing synthetic ammonia capacity to produce complex and compound fertilizers based on ammonium phosphate.

On the Continent of Europe controlled expansion has raised output to the levels obtained before last summer's curtailment. Stocks of ammonium sulphate and ammonium nitrate have been progressively reduced in recent months and accumulations are now non-existent at almost all major suppliers.

In West Germany further expansion of the Krefeld plant of Wasag-Chemie GmbH has been deferred. The effect of expansion plans in France has been evident in 1959 results and production of nitrogen is reported to have risen 11% compared with 1958. In Portugal new capacity of Ammoniaco Portuguese S.A. entered operations last spring substantially contributing to domestic supplies. In Spain the nitrogen industry is on the threshold of major expansion as several projects now under construction are making rapid progress. The large 20,000 tonnes N plant at Calvo Sotelo at Puertollano came on stream in November. Current demand totals 1½ million tonnes nitrogen fertilizer of which about two-thirds is imported. In Denmark—hitherto lacking a nitrogen industry and one of Europe's larger nitrogen importers—an ammonium sulphate project has been initiated near Copenhagen based on synthetic ammonia to be produced from oil refinery gases.

Middle and Far East

In these areas, comprising the main export markets, demand has been strong. A tender sale to South Korea covering about 65,000 tonnes N relieved some of the pressure of Japanese ammonium sulphate and urea supplies and these represented over one-half of the tender award. China purchased and shipped from Western Europe 400,000-500,000 tonnes material representing about one-third of the volume expected for the fertilizer year.

Construction activity is strong throughout these regions notably in India and China. In addition to the major nitrogen projects in India, a 51,000 t.p.a. ammonium phosphate plant has been commissioned recently; this is due to come on stream near Madras in 1961. In Iran E.N.S.A., to whom the Shiraz Nitrogen fertilizer project was awarded, aim to enter production in 1962. In Egypt the lime ammonium nitrate plant under construction by the German/French consortium is expected to be on stream early in 1961. The new urea plant at Chungju in South Korea is meeting considerable production difficulties. The output is only a fraction of designed capacity. The same

applies in Formosa at the Nankong plant which is the subject of a dispute between the Taiwan Fertiliser Co. and Hydrocarbon Research Inc., the plant contractors.

FREIGHT

The level of ocean freight rates which had advanced strongly during the boomlet from October to December, unexpectedly did not recede in the early months of this year. Continued grain deliveries, increased demand for iron ore tonnage and most recently sugar were the main contributory factors in supporting the level of freight rates. Substantial calls for the movement of fertilizers and fertilizer raw materials also added to the stronger tone of the freight market.

An indication of current rates for vessels of 10,000-12,000 tons is as follows :—

TO	*FROM*		
	Japan	*U.S.A.*	*W. Europe*
China	—	—	$8 - 8.50
South Korea ...	$2.50	$12†	$7.50 - 8
Spain	—	$6.47	24s.*
India	$8	$9.50 - 10	55s.
Central America ...	—	$13†	45s.

* Ravenna † U.S. Flag

A slight decline in freight rates is in evidence and further downward fluctuations are anticipated during the coming months although the market appears confident that until the seasonal decline in mid-summer there will not emerge a significant weakness.

PRICES

World Prices have advanced slightly. The shortage of immediate supplies in Western Europe is accompanied by a measure of restraint in the price policy of the major producers, who are anxious not to disturb the firm tone of the market. Localised centres of competition remain, such as one or two South and Central American markets, but in general the major producers avoid depressing prices by too severe competition. A typical example is Spain where, after prices fell sharply in December causing the authorities to increase the import duty, their level has risen once more. Pending the results of the spring season in U.S.A., the ability of Japan to place its continued surplus and the extent of China's import demand, the outlook is cautious but it is now generally believed that since last year's slump the market has turned.

Domestic Prices

UNITED STATES

Scheduled prices by manufacturers have advanced seasonably. Since January ammonium nitrate is posted at $68. Anhydrous ammonia remains in severe competition in the Central Valley of California where Best Fertiliser Co. charges $72 per short ton delivered to consumers. Elsewhere in the U.S.A. fertilizer grade anhydrous ammonia is quoted at $86 per short ton in tank cars ex-works, and refrigeration grade $2.50 more. Posted prices are as follows :—

	per short ton f.o.b.
Coke oven ammonium sulphate ...	$ 32 in bulk
Synthetic ammonium sulphate ...	$ 35 in bulk
Ammonium nitrate	$ 68 in bulk
Nitrogen solutions (40.8% N basic 100%)	$128 in tank cars

The price of lime ammonium nitrate and sodium nitrate is $48 per short ton f.o.b. works or port. Fertilizer grade urea (46%N) is quoted $103 per short ton delivered.

UNITED KINGDOM

Current quotations for material delivered to farmers' nearest railway stations are:—

	per ton	*subsidy*
Ammonium sulphate (21% N)	£21 5s. 0d.	£9 19s. 6d.
Nitro chalk (15.5% N) ...	£18 10s. 0d.	£7 7s. 3d.
Nitro chalk (21% N) ...	£27 0s. 0d.	£9 19s. 6d.
Kaynitro (16% N-16% K_2O)	£26 17s. 6d.	£7 12s. 0d.

WESTERN GERMANY

Current quotations for material delivered to farmers' nearest railway stations are:—

	D.M. per tonne N Feb. - June
Ammonium sulphate (21% N)	1,190
Ammonium sulphate nitrate (26% N) ...	1,200
Lime ammonium nitrate (20.5% N) ...	1,225
Calcium nitrate (15.5% N)	1,360
Calcium nitrate (16% N)	1,400
Urea (46% N)	1,190

BELGIUM

Current quotations for material delivered to farmers' nearest railway stations are:—

	Belg. Francs per 100 kgs.		
	Jan.	*Feb.*	*March-June*
Ammonium nitrate ...	240	244	247
Ammonium sulphate ...	233	237	240
Calcium Cyanamide (18%)	330	332	332
Calcium Cyanamide (22%)	381	381	381

EXPORT MARKETS

Ammonium Sulphate

Market prices range from $31 to $38 per tonne f.o.b. in bulk, mostly confined to the upper half of the bracket. Sales to China in

recent months showed a slight decrease of about 2s. 6d. per tonne. The price posted by the majority of Western European producers is £11 15s. ($32.90) per tonne f.o.b. in bulk.

Sales to Spain are reported at $35 per tonne f.o.b. in bulk. Since January the import duty is Gold pesetas 5.15 per 100 kgs. (equivalent £2 3s. 6d. per tonne) having risen from Gold pesetas 2.39 per 100 kgs. established last summer when imports were liberalised.

In Greece, Italy (ANIC) secured 35,000 tonnes under the tender of the Agricultural Bank in February at $40.25 per tonne c. & f. packed in 100 kg. jute bags. The tender held in January in respect of sales to South Korea included 117,305 tonnes of ammonium sulphate all of which was secured by Japan at prices of $39.50-40.50 per tonne f.o.b. and c. & f. terms based on freight charges of $2.50 in foreign flag ships and $8.50 in U.S. vessels. Ammonium sulphate nitrate from Western Germany was sold to South Korea at $52 per tonne c. & f. The price basis is $4 per tonne lower than in last autumn's sale.

Ammonium Nitrate

Current quotations range from $56 to $63 per tonne f.o.b. Only 10,000 tons of this material was included in the January tender sales to South Korea and this was secured by U.S. supplies at $78.10 per tonne c. & f. In the Greek tender France sold 12,000 tonnes at $61.30 per tonne c. & f. in 50 kgs. lined jute bags. Lime ammonium nitrate prices in W. Europe have advanced slightly as stock accumulations were being reduced. Current quotations range from $33 to $37.50 per tonne f.o.b. in bags. Offers to South Korea included material from Italy (SEIFA) and Austria at $33 per tonne.

Calcium Nitrate

A small parcel (5,000 tonnes) was sold in the February tender by Norway to Greece at $35.50 per tonne c. & f. packed in jute bags.

Urea

Strong world-wide demand has caused an advance of urea prices of up to $7 per tonne from last autumn's levels. Japan sold 40,000 tonnes to South Korea based on $84 per tonne f.o.b. Of the balance, 17,600 tonnes was awarded to Dutch suppliers on a basis of $83 per tonne f.o.b. and 3,000 tonnes to U.S. suppliers at $86.48 per tonne f.o.b.

United States. Aerial view of the Adams Terminal ammonia plant of the Phillips Chemical Co. In the left background are other units of the company including ammonium sulphate and methylvinylpyridine plant and the terminating facilities of the Houston Ship Canal.

Expanding Activities of W. R. Grace & Co.

INCREASING capacity in the United States and participation in overseas production mark the current phase of expansion in the nitrogen field by the Chemical Division of W. R. Grace & Co. of New York. The interests of the parent company cover industrial chemicals, a wide range of commercial activities in Latin American countries, shipping, airlines, banking, insurance and advertising, while its Davison Chemical Company Division is a major superphosphate manufacturer. Chemicals account for over one-third of the total revenue of W. R. Grace & Co. and of this fertilizer chemicals account for over one-half.

Ammonia

Nitrogen production facilities of the Grace Chemical Division are located at Woodstock near Memphis, Tennessee. Built by Foster Wheeler Corp. of New York and completed in 1956, these works have an annual capacity of 100,000 tons of anhydrous ammonia based on the use of methane. New installations raising this capacity to over 160,000 tons a year are expected to be in operation by 1961 and will make the Woodstock Works the fifth largest nitrogen plant in the United States and among the twelve largest in the world. These new facilities will parallel the existing ammonia train and result in economies by integration at several stages of the operations, although the new ammonia train will be capable of independent production.

The process selected comprises five major stages as follow:—

1. Primary and secondary high pressure (130 lbs. per sq. inch) steam methane reforming.
2. Two steps of carbon monoxide shift conversion, each followed by a stage of carbon dioxide removal by monoethanolamine.
3. Methanation of residual carbon monoxide.
4. Synthesis gas compression.
5. Ammonia synthesis at 9,000lbs. per sq. inch by the Casale process.

The new sequence will differ from the existing facilities principally in that it will employ steam methane reforming in place of a partial oxidation process. It is also reported that an unusual feature of the design will be the use of a cooling tower, equipped with grids of high density polyethylene.

Design and construction of the new ammonia train has been entrusted to Foster Wheeler Corporation although sub-contracting is not yet complete.

The expansion of ammonia capacity at Woodstock follows the doubling of urea capacity at these works and will meet the increased requirements for ammonia, both for use in urea manufacture and in the preparation of other nitrogenous fertilizers. The increased ammonia requirements of the expanded urea facilities at Woodstock have hitherto necessitated the purchase of additional supplies from other producers. Demand for ammonia for technical applications continues to grow and has been another factor in influencing the decision to increase capacity.

Urea

Capacity of the urea facilities at Woodstock were doubled in the summer of 1959 with the completion of a 55,000 ton per year unit. Both urea units at these works were designed and erected by Foster Wheeler Corp. and employ the Pechiney total recycle process. In the design of the new unit, however, engineers of the Grace Chemical Co. have collaborated with Foster Wheeler and Cie. Pechiney, licensors of the process, to incorporate a number of technical improvements derived from experience gained in the operation of the original installations. These improvements are now licensed jointly by Grace and Pechiney.

Urea is produced at the Woodstock plant in four principal forms : treated and untreated prills with a nitrogen content of 45% for fertilizer use, prills with nitrogen content of 42% for cattle feed and crystals with a nitrogen content of 46% for industrial use. The Grace Chemical Division has played an important part in pioneering the use of urea as a cattle feed supplement. This application now accounts for 100,000 tons a year or one-ninth of the total United States consumption of urea.

Trinidad

Early in 1959 Federation Chemicals Ltd., a subsidiary of W. R. Grace & Co., commissioned a nitrogen fertilizer plant at Port of Spain, Trinidad, with an annual capacity of 85,000 tons of ammonium sulphate and 25,000 tons of urea. Ammonia is produced from refinery waste gas by the M. W. Kellogg process, urea being manufactured by the Stamicarbon process, a "once through" arrangement whereby unreacted ammonia is available for conversion to ammonium sulphate.

Investment in the Trinidad plant by W. R. Grace & Co. has amounted to some £7 million representing approximately 80% of the total capital required. Another £1 million has been invested by the Colonial Development Corporation. It has been anticipated that fertilizers produced in Trinidad will find a growing market in the British West Indies and in Central America.

Puerto Rico

The nitrogen interests of W. R. Grace & Co. are being extended to Puerto Rico, following the recent signing of a contract with Gonzalez Chemical Industries Inc., since re-named the Caribe Nitrogen Corporation, under which Grace will manage and operate the ammonia and ammonium sulphate facilities at Guanica. This contract is a first step in the contemplated reorganisation of the Caribe Nitrogen Corporation, in the course of which it is expected that Grace will acquire a substantial stock holding in the Puerto Rican company.

The Gonzalez plant was designed and built by the Lummus Co. of New York in 1956, with a designed capacity of 125 tons per day of anhydrous ammonia and 350 tons a day of sulphuric acid primarily for use in the manufacture of over 400 tons of ammonium sulphate a day. Ammonia and sulphuric acid are also available for industrial use. Built at a cost of $12 million, the plant is the only nitrogen installation in Puerto Rico. Hydrogen for ammonia synthesis is obtained from fuel oil by the Texaco partial oxidation process, sulphuric acid being manufactured from brimstone by the Leonard-Monsanto process.

Australia

An extension of W. R. Grace interests to Australia is possibie following the current examination of a proposal to join Mount Morgan Ltd. as a partner in a £6 million nitrogen fertilizer project. Examination of the Mount Morgan project is being made through Dewey & Almy Overseas Inc., a subsidiary of W. R. Grace & Co. If the report is favourable, Grace has agreed to partner Mount Morgan Ltd. in finding the necessary equity capital to proceed with the erection of the plant.

Considerable attention has for some time been focussed on the possibility of using pyrites concentrates from the Mount Morgan mine to manufacture ammonium sulphate or ammonium phosphate at Rockhampton, some 25 miles distant. Hydrogen for ammonia synthesis could be obtained from nearby lignite deposits but the use of fuel oil has also been considered; power and good transport facilities are also available.

According to one of the estimates for this project, the Rockhampton plant would cost £5.3 million and ammonium sulphate could be placed in Queensland, the biggest consuming area, produced at approximately £10 less than the current price of imported or domestic material shipped by coaster into this market. Alternative plans envisage the manufacture of ammonium nitrate or urea in addition or as an alternative to ammonium sulphate. Participation in this project would raise the capacity of the combined nitrogen installations, wholly or partially owned by W. R. Grace & Co., to over 200,000 tons of nitrogen a year.

Summary

In the past American chemical firms have not participated to any great extent in nitrogen production overseas. Intensifying competition in export markets, despite the steadily rising world demand for nitrogen fertilizers, may encourage United States producers to follow W. R. Grace & Co. in participating in some of the increasing number of fertilizer plant projects, particularly in under-developed areas. In meeting from local production the considerable demand anticipated for nitrogen fertilizers in Africa, Asia and Central and South America, this policy may well offer United States producers the most effective method of coupling capital investment with an assured market.

Sahu Chemicals Ammonium Chloride Plant on Stream

THE AMMONIUM CHLORIDE PLANT, with a capacity of 40,000 tonnes a year and built for Sahu Chemicals Ltd. at Varanasi in Benares State, came into operation in the summer of 1959. Coke, gasified in rotary-grate generators, provides the hydrocarbon feed stock for the ammonia synthesis unit which has a capacity of 40 tonnes a day. Desulphurization, carbon monoxide conversion under pressure and carbon dioxide removal using a potassium carbonate

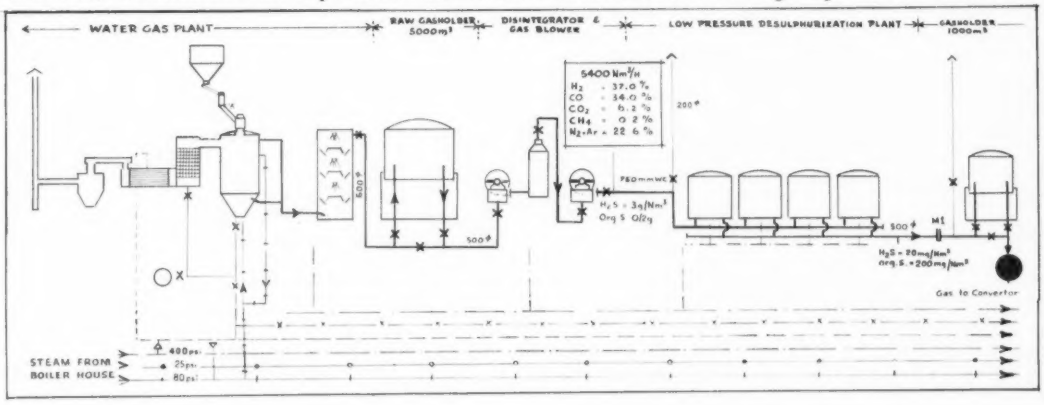


Fig. 6. Production, purification and storage of crude gas.

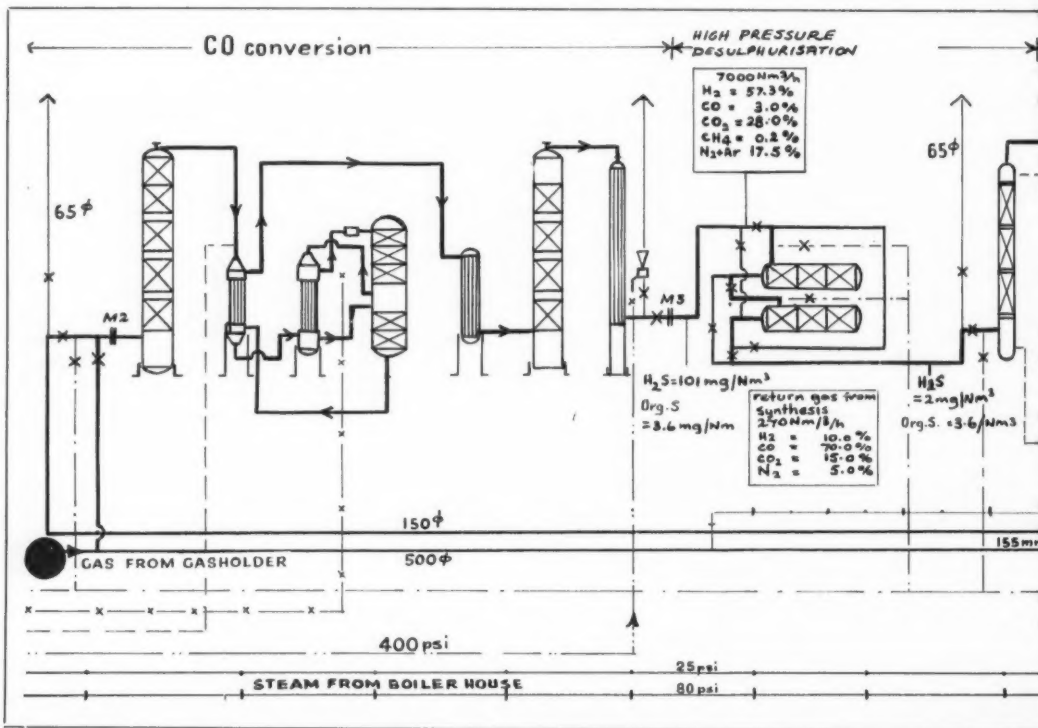
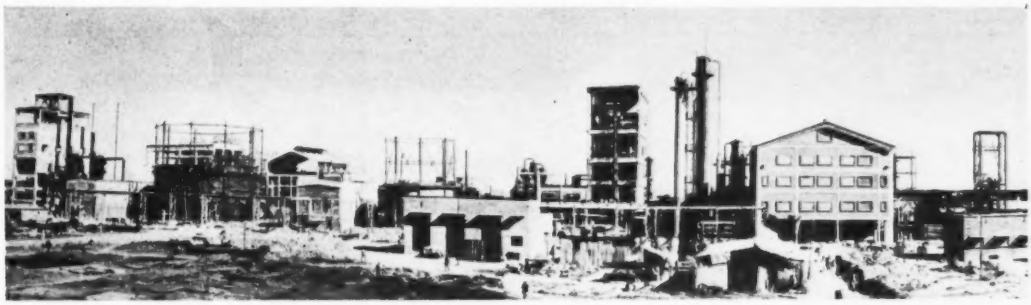


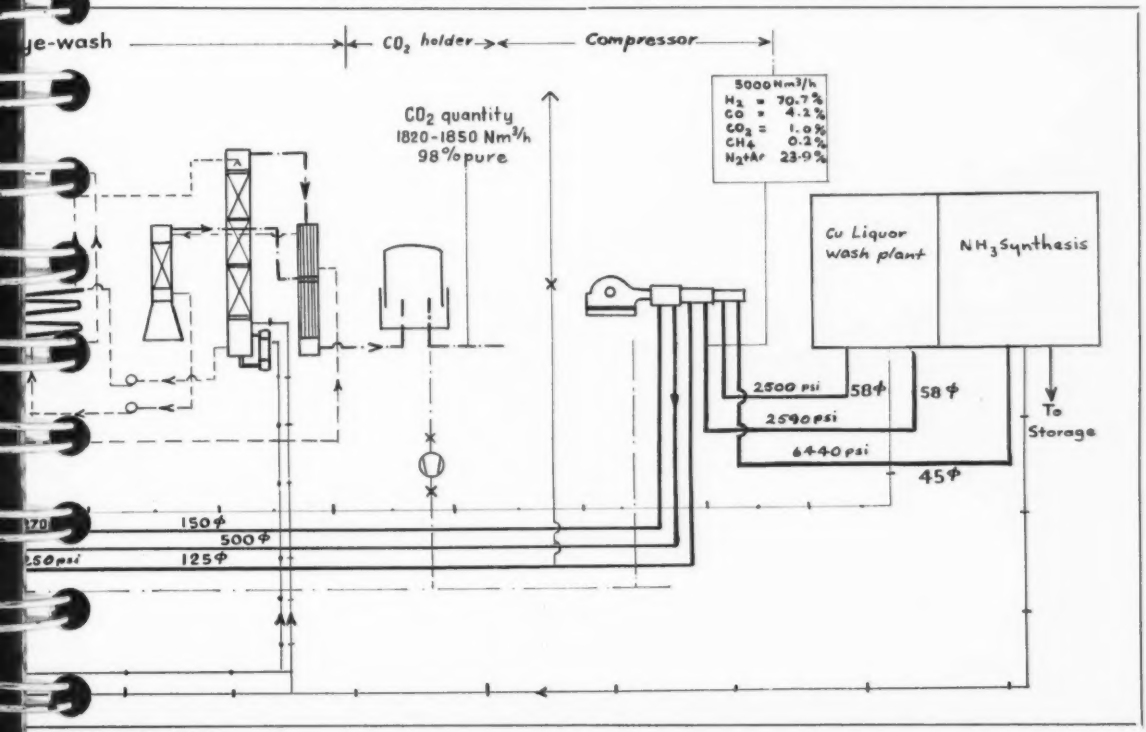
Fig. 7. Conversio

solution are followed, after further compression, by final purification of the feed gas. This is carried out at a pressure of 170 atmospheres using an ammoniacal copper solution. The purified synthesis gas is further compressed and then piped to the ammonia synthesis unit which operates at a maximum pressure of 450 atmospheres. All the ammonia produced is used in the manufacture of ammonium chloride and soda; carbon dioxide recovered in the potassium carbonate scrubbing operation being re-used in the reaction.

The coke preparation and handling equipment, gas generators, desulphurization plant, carbon dioxide conversion unit, potassium carbonate scrubbing unit, gasholders and compressors were all supplied by Messrs. Pintsch Bamag A.G. of Butzbach, West Germany. The copper solution scrubbing equipment and ammonia synthesis unit were supplied by Messrs. Friedrich Uhde GmbH of Dortmund. The ammonium chloride and soda plant was designed by the plant operators themselves.



General view of the ammonium chloride plant at Varanasi during construction.



nd compression.

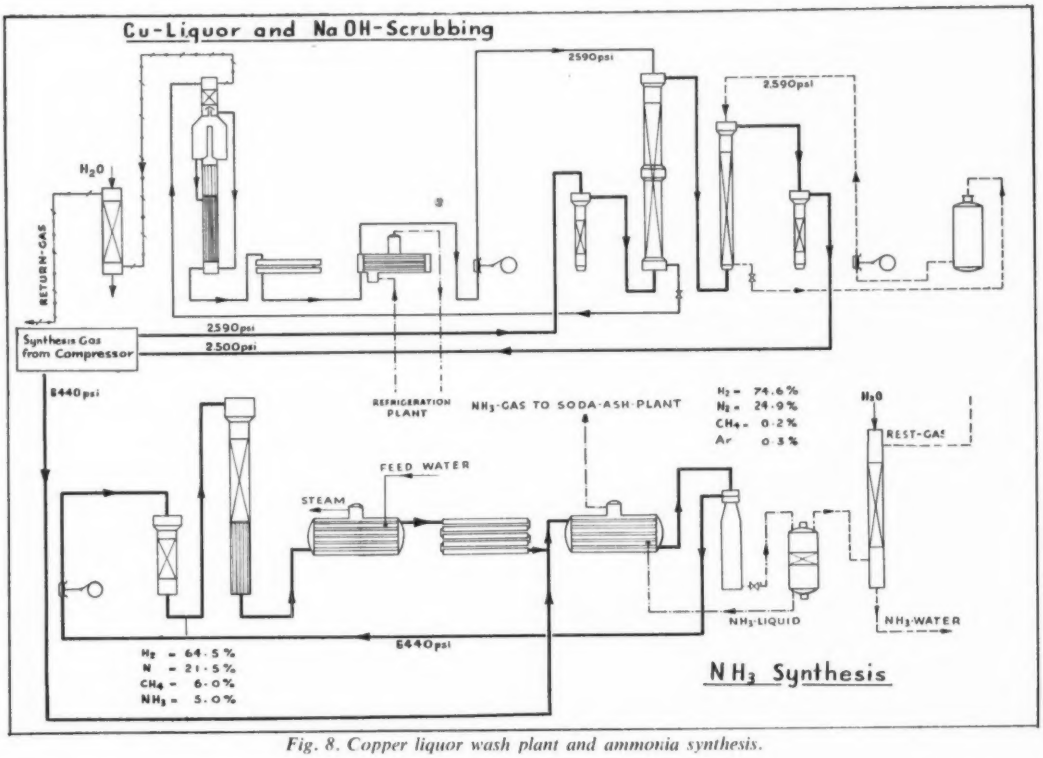


Fig. 8. Copper liquor wash plant and ammonia synthesis.

Ravenna

FERTILIZERS IN A PETROCHEMICAL COMPLEX

ONE OF THE largest nitrogen fertilizer works in Western Europe, the new plant completed for ANIC at Ravenna in 1959 may well foreshadow the future development of the Nitrogen Industry towards the maximum integration of production with other manufacturing operations. At Ravenna this trend is exemplified by the interdependence for raw materials between ammonia production and the manufacture of synthetic rubber, which is designed to afford important economic advantages.

With an annual capacity of 150,000 tonnes of nitrogen and 60,000 tonnes of synthetic rubber, this $48 million petrochemical complex was established to use the abundant supplies of natural gas in the Po Valley as part of a far-reaching scheme of expansion outlined by Snr. Enrico Mattei, President of ANIC and of its parent organisation, ENI.

ANIC

Originally formed for the production of synthetic rubber, utilizing hydrocarbons obtained as by-products of petroleum refining, ANIC is a component of the State-owned ENI, which itself controls the natural gas supplies from the Po Valley and through other subsidiaries is engaged in the production, refining and marketing of petroleum products. The project was recast on its present basis in 1954 when it was considered that the Italian oil refineries would be unable to supply, economically, enough raw material to meet the requirements of the plant on its original basis of an annual capacity of 30,000 tonnes of synthetic rubber. By turning to the use of methane from natural gas it was possible to raise the planned capacity for synthetic rubber to 40,000 and subsequently to 60,000 tonnes a year and to provide in addition for the manufacture of 650,000 tonnes of nitrogen

fertilizers. The methane content of the natural gas in the Po Valley is as high as 99% and the availability of cheap supplies is the basis of the commercial strength of the Ravenna enterprise.

Plant Site

Approximately four kilometres north-east of Ravenna the plant is situated alongside the Corsini Canal connecting the city with the Adriatic. The total area of the site exceeds 530 acres, two-thirds of which has been set aside for future expansion. Before its development one-half of the plant site comprised marsh land and drainage canals and the presence of water about one metre below the surface of the ground necessitated the extensive use of foundation piles.

The plant site on the Corsini Canal facilitates both the intake of raw materials and the dispatch of finished products. At present ships of up to 5,000 tons can use the canal, but plans are well advanced to widen and deepen it to enable vessels of up to 15,000 tons to dock at the works.

Raw Materials

Natural gas is supplied by pipeline from wells in the Po Valley. Gypsum is obtained from beds only a few miles from Ravenna where quarries have been opened and crushing equipment installed, supplies being taken to the plant by road and rail. Other raw materials, including sulphuric acid, caustic soda, sodium chloride, limestone, coke and activated carbon, are purchased in substantial quantities.

Air Fractionation

A Linde fractionation unit working at low temperature and pressure is employed to split air into nitrogen and oxygen. No auxiliary refrigerating cycle is required and energy is recovered from the generator connected to the nitrogen expansion turbine. The separated gases are stored in two gasometers, each of 10,000 cubic metres capacity. Oxygen of 98% purity is fed to the partial oxidation unit and to the acetylene plant, while the nitrogen, 99.8% pure, is supplied to the ammonia synthesis gas installations.

Synthetic Rubber

Butadiene for use in the manufacture of synthetic rubber is obtained by two different routes at Ravenna. One, employing a process licensed to ANIC by the Union Carbide Corporation of the United States, involves the partial hydrogenation of acetaldehyde and the conversion of the acetaldehyde-alcohol mixture into butadiene. The other, involving the purification of *n*- butane, its dehydrogenation and compression with subsequent separation and recovery of butadiene with furfural absorption, is operated under licences granted

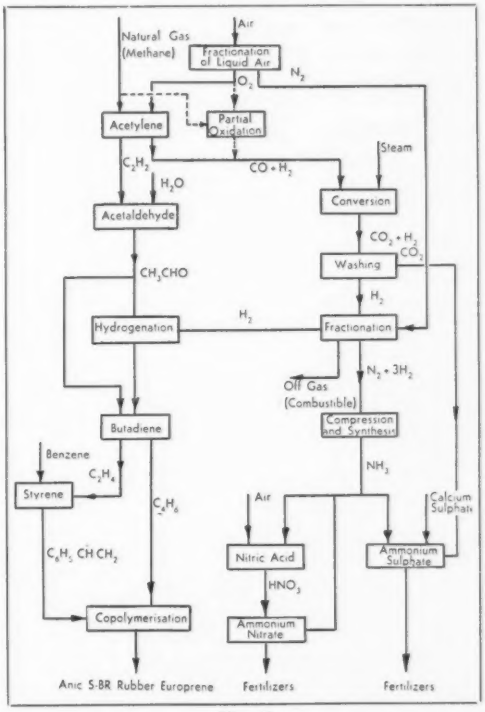


Fig. 9.

by the Houdry Process Corp., of Philadelphia, Pennsylvania, and the Phillips Petroleum Co. of Bartlesville, Oklahoma.

The preparation of synthetic rubber involves the copolymerization of butadiene and styrene. The latter is produced at Ravenna from ethylene and benzene by a process licensed to ANIC by the Koppers Company. The production cycle has two stages: the synthesis of ethylbenzine from ethylene and benzene and the dehydrogenation of ethylbenzene to styrene. Production of synthetic rubber at Ravenna started in 1957 and is to be gradually increased to meet the anticipated growth of demand, particularly within the Common Market area.

Ammonia Synthesis

Hydrogen for ammonia synthesis is obtained by the direct partial oxidation of methane and as a by-product from the acetylene plant. After steam conversion the mixture is decarbonized by washing with water and soda. It is then passed to a low temperature fractionation plant where, after condensation, it is washed with liquid nitrogen to remove the residual carbon monoxide. The mixture of nitrogen and hydrogen is then adjusted by the addition of further nitrogen to bring it to the ratio required for ammonia synthesis.

In the same fractionation plant high purity hydrogen for use in the partial transformation of acetaldehyde to alcohol is obtained with the partial condensation of nitrogen involving a reduction in temperature to −200°C. This step is another feature of the inter-relation between the two principal production sequences at Ravenna. The gas is then compressed to between 400 and 500 atm. and is fed to Casale type reactors, yielding liquid anhydrous ammonia.

Ammonium Nitrate

Nitric acid is produced in a Uhde type plant consisting of two parallel high-pressure units operating at 5 kg./cm. and employing an adaptation of the Du Pont process. Ammonium nitrate is produced in a plant with a capacity of 132,000 tonnes a year and is either prilled or further processed to lime ammonium nitrate.

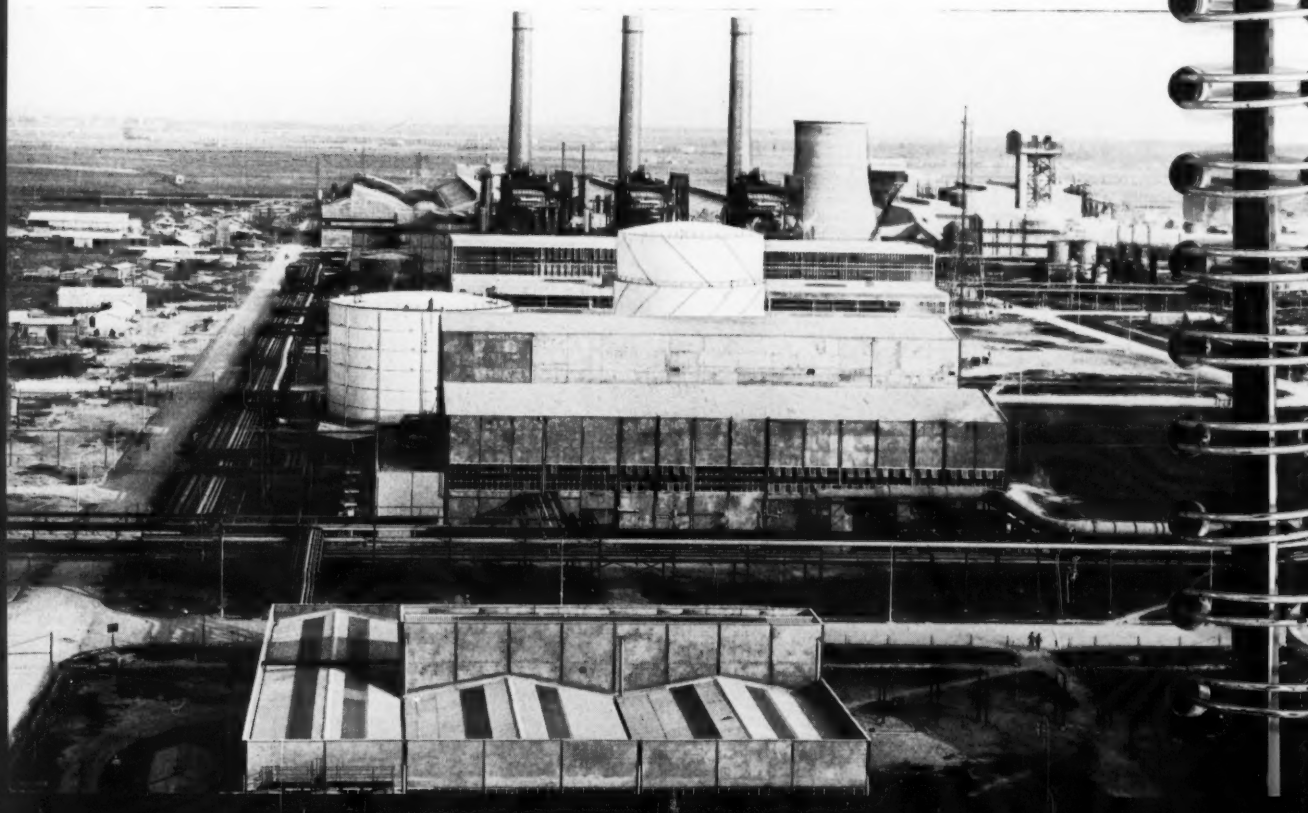
Ammonium Sulphate

Production of ammonium sulphate at Ravenna started in 1959 in a plant with a capacity of 400,000 tonnes a year employing a process developed by Imperial Chemical Industries Ltd. and in use at their Billingham works, whereby ammonia reacts with carbon dioxide and gypsum.

Complex Fertilizers

The process developed by Société Potasse et Engrais Chimiques is used at Ravenna for the manufacture of complex fertilizers. Phosphate rock is acidulated with nitric acid, the resulting solution being neutralized with ammonia until the desired nitrogen content is reached. Ternary complex fertilizers are obtained by the addition of potassium chloride or potassium sulphate. The final product contains dicalcium phosphate, soluble in

General view of a section of the petrochemical comple[illegible] at



ammonium nitrate, together with ammonium nitrate and potassium nitrate. Additional calcium not bound to the dicalcium phosphate is present in the form of calcium carbonate. The complete absence of calcium nitrate in this fertilizer material ensures free-flowing, non-caking qualities. 50% of its nitrogen content is in the form of ammonia nitrogen and 50% in the form of nitrate nitrogen, although it is possible to obtain a product containing only ammonia nitrogen.

Services

Water required at the Ravenna works for cooling, as process water and for use in boilers is pumped from the River Reno at a rate of up to 500,000 imp. gallons an hour, and is supplied by way of a 9½-mile long canal. Cooling water is conserved by employing four natural draught and five forced draught cooling towers.

Excess nitrogen from the air fractionation plant is used for all instrument lines in place of compressed air and also as an inert atmosphere for blanketing the styrene tanks.

Electric power is supplied from a station consisting of three methane burning boilers each working at 120 atm. and at a superheated temperature of about 530°C with a steam output of 270 tonnes per hour. Steam is expanded through back pressure turbines with a rating of 120,000 KVA at 15,000 volts. Steam is also drawn off at a pressure of 40 atm. and at a temperature of 400°C for use in back pressure turbines providing power for turbo compressors in the chemical installations. A sub-station transforms to 6,000 and 380 volts for the national network. Thermoelectric power supplies at the Ravenna works are, however, appreciably in excess of present plant requirements and this points to future expansion.

Lower Production Costs

The practice of nitrogen fertilizer production as an auxiliary to the manufacture of a more valuable product is a relatively new concept, although it has already become established in West Germany and Holland. Appearing particularly suited to the scale of operations prevailing in Europe, this practice aims at lowering production costs at a time when the nitrogen fertilizer market has become increasingly competitive.

at Ravenna. Fertilizer plants centre middle distance.

THE SUMITOMO CHEMICAL COMPANY

Expansion and Diversification

ONE OF THE largest nitrogen producers in Japan and the eleventh largest chemical combine in the world, the Sumitomo Chemical Co. Ltd. is itself a member of the Sumitomo group of companies whose activities range from coal-mining, steel production, metallurgy, heavy and electrical machinery, sheet glass production and atomic energy research to banking, insurance, forestry, real estate and warehousing. Like several other companies in the Sumitomo group, the Sumitomo Chemical Co. sprang from the Besshi copper mining enterprise, being formed in September 1913 to use sulphuric acid obtained from sulphur dioxide generated in the process of smelting copper ore. A works to manufacture calcium superphosphate was established at Niihama on Shikoku Island, while in June 1925 the enterprise was reorganized as the Sumitomo Fertilizer Works Ltd.

Following the acquisition in 1928 of a licence from the Nitrogen Engineering Corporation of the United States for their ammonia synthesis process, nitrogen production started at Niihama in 1930. The company started the manufacture of ammonium sulphate in 1931, of nitric acid in 1934, of sodium nitrate in 1935 and of ammonium nitrate in 1941. In order to finance the expansion of production facilities, the company increased its capital to ten million yen in 1934, changing its name to the Sumitomo Chemical Company in the same year.

During World War II the installations at Niihama suffered heavily from air raids and after 1943 from inadequate maintenance, but an extensive rehabilitation programme was put into operation in 1945 with the emphasis being placed on the restoration and expansion of ammonia and ammonium sulphate facilities. At the same time the "Konzern," or holding company, which had controlled all the Sumitomo interests was dissolved by the Occupation Authorities and the Sumitomo Chemical Company became independent, but connected to other companies in the group by interlocking share holdings and close personnel relationships. To-day the company manufactures fertilizers and industrial chemicals at Niihama,

Aerial view of the works at Niihama.

Kikumoto and Osaka and has expanded far beyond the limit of its pre-war operations.

Niihama Works

Employing the Chemico process, the capacity of the ammonia synthesis installations at Niihama now amounts to 150,000 tonnes a year, based on the use of natural gas. A recent development has been the use of residual gas from polyethylene production as a raw material in the ammonia synthesis plant, thereby further reducing production costs. Ammonium sulphate is manufactured using sulphuric acid and production capacity has been raised to 486,000 tonnes a year.

Nitric Acid and Ammonium Nitrate

Monthly production capacity of nitric acid at Niihama is now 2,200 tonnes composed of 98% (48° Bé), 67.5% (42° Bé) and 62% (40° Bé) acids, with increasing quantities of diluted acid being exported in bulk to markets in South-East Asia. Ammonium nitrate capacity is now 43,000 tonnes a year, much of which is in prilled form. Production at these works now accounts for over half the total Japanese output.

Urea

In 1950 an investment of 700 million yen was made in a urea plant with annual capacity of 65,000 tonnes, employing the Chemico process. The product, with a guaranteed nitrogen content of 46%, is prilled for fertilizer use and coated with an anti-caking agent. Increasing quantities of urea are also being made available for technical use.

Compound and Complex Fertilizers

A wide range of mined and complex fertilizers is manufactured at Niihama and production capacity for these materials is now 231,000 tonnes a year. The range includes the following fertilizers :—

	Total nitrogen	*Ammonia nitrogen*	*Soluble phosphate*	*Water soluble phosphate*	*Citric soluble phosphate*	*Water soluble potassium*
Ammonium phosphate	16.0	16.0	20.0	17.0	—	—
Ammonium phosphate potassium ...	12.0	12.0	12.0	11.0	—	10.0
Ammonium phosphate potassium ...	13.0	13.0	13.0	11.5	—	13.0
Ammonium phosphate potassium ...	15.0	15.0	8.0	7.0	—	8.0
Ammonium phosphate potassium ...	12.0	12.0	8.0	6.0	—	7.0
Urea compound fertilizer	10.0	1.0	—	5.0	10.0	10.0
Ammoniated calcium superphosphate	3.0	3.0	—	13.0	20.0	—

A complete fertilizer for leaf application has recently been developed at Niihama. Mainly composed of mon-ammonium phosphate and potassium with guaranteed components of 21% T.N., 21% S.P. and 14% W.K., it is the only fertilizer of its type manufactured in Japan.

Acrylonitrile

Plant has recently been installed for the manufacture of acrylonitrile in a plant with a capacity of 20 tonnes a day based on the use of hydrogen cyanamide gas and acetylene. The acrylonitrile monomer is supplied to a 50% owned subsidiary, the Japan Exlan Co., for use in the manufacture of the acrylic fibre Exlan, similar to the Creslan produced by the American Cyanamid Co. The joint owner of the Japan Exlan Co. is the Toyo Spinning Co., the largest enterprise in this field in Japan. Other products of the Niihama plant include methanol, formalin, ammonium bicarbonate and sodium nitrate for technical use.

Kikumoto and Osaka

At the Kikumoto works the emphasis is on aluminium and alum products although limited quantities of ammonia are used, chiefly in the manufacture of ammonium alum. At Osaka, technical urea from Niihama is used in the production of the following synthetic resins for shrinkage control and anti-wrinkle finishing of textiles :—

Sumitex Resin 450 }
Sumitex Resin 850 } urea resins
Sumitex Resin 880 }
Sumitex Resin F-5 cyclic urea resin
Sumitex Resin 501 melamine — urea resin

Technical urea is also used in the manufacture of Sumitex Resin 614, a urea-resin for imparting wet-strength to paper. Other products at these works include dyestuffs, discharging agents, chemical intermediates, pharmaceuticals and agricultural chemicals.

Recent Expansion

A notable feature of the development of the Sumitomo Chemical Company during the last eight years has been the steady expansion of nitrogen production accompanied by increasing diversification in all fields.

Among nitrogen products the emphasis is on urea which has accounted for the largest share of the rising ammonia output. Further expansion can be expected from the Sumitomo Chemical Company with the growing demand for fertilizers and industrial chemicals in South-East Asia and it is likely that both ammonium nitrate and urea will assume increasingly important positions in the pattern of production at Niihama. Ammonium nitrate is also likely to assume an increasingly important part in production at Niihama. With the growing demand for fertilizers and industrial chemicals in South-East Asia, the Sumitomo Chemical Co. is expected to continue its impressive expansion.

Product	*tonnes per year*
1. Niihama	
Ammonia	150,000
Nitric acid (100% HNO_3)	29,000
Ammonium nitrate	43,000
Ammonium sulphate	486,000
Urea	65,000
Calcium superphosphate	452,000
Compound fertilizers	231,000
Sulphuric Acid (98%)	340,000
Methanol	34,000
Formalin	27,000
2. Kikumoto	
Aluminium	20,000
Polyvinyl chloride	14,000
Aluminium sulphate	36,000
3. Osaka	
Synthetic resins	11,844
Dyestuffs	6,751
Parathion	1,080
4. Obe	
Polyethylene	11,000

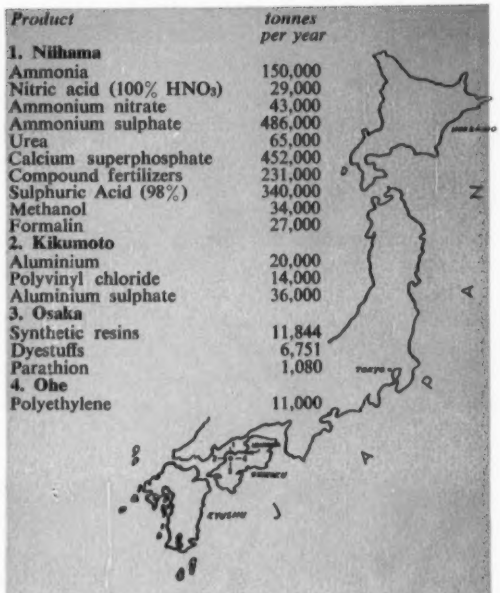


Fig. 10. Annual Current Capacities.

Sumitomo Chemical Company. Production 1952 - 1959

(tonnes)

	Anhydrous ammonia	*Nitric Acid (100% HNO_3)*	*Ammonium nitrate*	*Ammonium sulphate*	*Urea*
1952	35,764	14,630	15,341	236,212	1,450
1953	86,297	18,422	21,434	195,487	8,029
1954	93,427	19,502	24,899	178,791	21,655
1955	92,873	18,455	21,902	164,813	30,905
1956	112,649	19,588	24,834	208,885	38,398
1957	127,575	19,977	24,231	230,651	45,675
1958	133,467	18,587	25,171	226,063	53,802
1959	138,154	21,341	28,133	218,548	52,520

AMMONIUM NITRATE PROCESS AND PLANT

BY THE

Société Belge de l'Azote

ONE OF THE first firms in the world to manufacture synthetic ammonia, the Société Belge de l'Azote et des Produits Chimiques du Marly (S.B.A.) of Liège, operate works at Marly and Renory with a combined capacity of over 90,000 tonnes of nitrogen a year. The Marly works manufactures ammonium sulphate, ammonium nitrate, ammonium sulphate nitrate, compound fertilizers and nitric acid, while the Renory works manufactures ammonium sulphate and ammonium nitrate. Production at both works is based on the use of coke-oven gas.

In addition to its role as a major nitrogen fertilizer manufacturer, the largest in Belgium, the Société Belge de l'Azote et des Produits Chimiques du Marly licences a number of processes, of which one of the most important is that for the manufacture of ammonium nitrate. Affording the means of

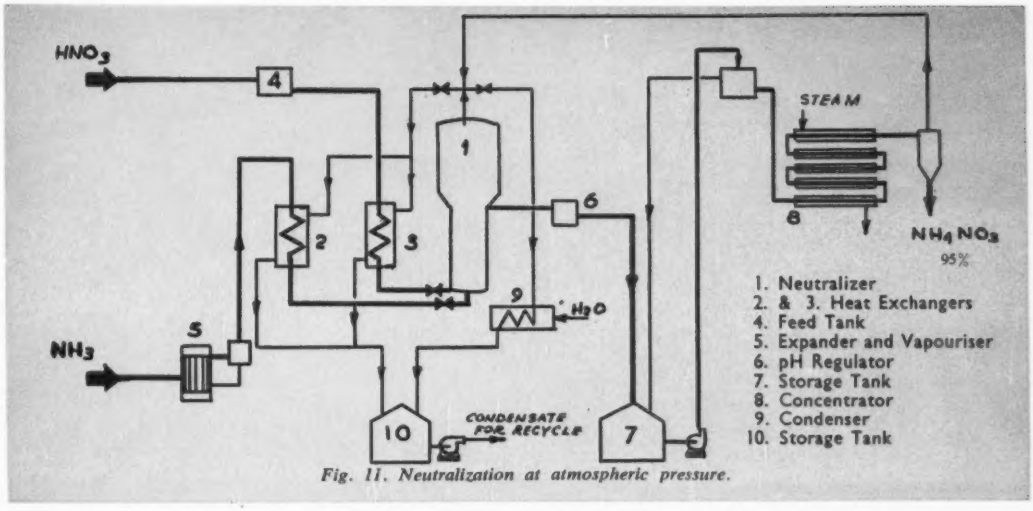


Fig. 11. Neutralization at atmospheric pressure.

producing the full range of granular nitrate fertilizers containing from 16 to 34.5% N, the process comprises two principal stages; the production of concentrated ammonium nitrate solution by neutralization of nitric acid and ammonia and the subsequent conversion of this product to homogeneous prills.

Neutralization

Neutralization by the S.B.A. process of nitric acid with ammonia is accomplished either at atmospheric pressure or at a pressure of approximately 4 atm., depending on local conditions and economic requirements. The use of a pressure process affords the important advantage of being independent of external steam requirements, the heat of reaction being used for preheating the nitric acid and ammonia and for concentration of the ammonium nitrate solution. These conditions are already assured if one uses nitric acid diluted to a strength below 50% HNO_3 by weight. With the use of more concentrated acid, the process affords an excess of low pressure which is available for use in other sections of the works. As an example, when using acid at a strength of 54% HNO_3 this steam output reaches a level of about one tonne for every tonne of ammonia used. Such a system is clearly advantageous when using ammonia under pressure.

On the other hand, the use of atmospheric pressure affords lower capital cost and is recommended when the cost of steam is not an important factor.

Neutralization at Atmospheric Pressure

Gaseous ammonia at a pressure of 1 atm., together with nitric acid, is fed into the bottom of the neutralizer, both these materials having been pre-heated in tubular heat exchangers using some of the steam obtained by the heat of neutralization. Nitric acid is supplied from a feed tank assuring a constant pressure on entering the neutralizer. If ammonia is supplied in liquid form the plant would be equipped with an expander and vaporizer using water as the heating medium.

The neutralizer is a simple, stainless steel vessel equipped with a static centrifuge to ensure rapid circulation and intermixing of the ammonia and nitric acid. Steam is given off from the top of the neutralizer, while the ammonium nitrate solution is discharged from the side by a pipe fitted to ensure the maintenance of a constant level in the vessel.

At this stage the solution has a concentration of approximately 83%, the pH level is then adjusted in a tank into which ammonia is injected in sufficient quantity to obtain an absolutely neutral solution. This solution is then stored in a tank from which it is pumped to a concentrator consisting of a series of coiled pipes enclosed in a double-walled casing through which live steam is circulated at a pressure of 14 atm. A separator built into

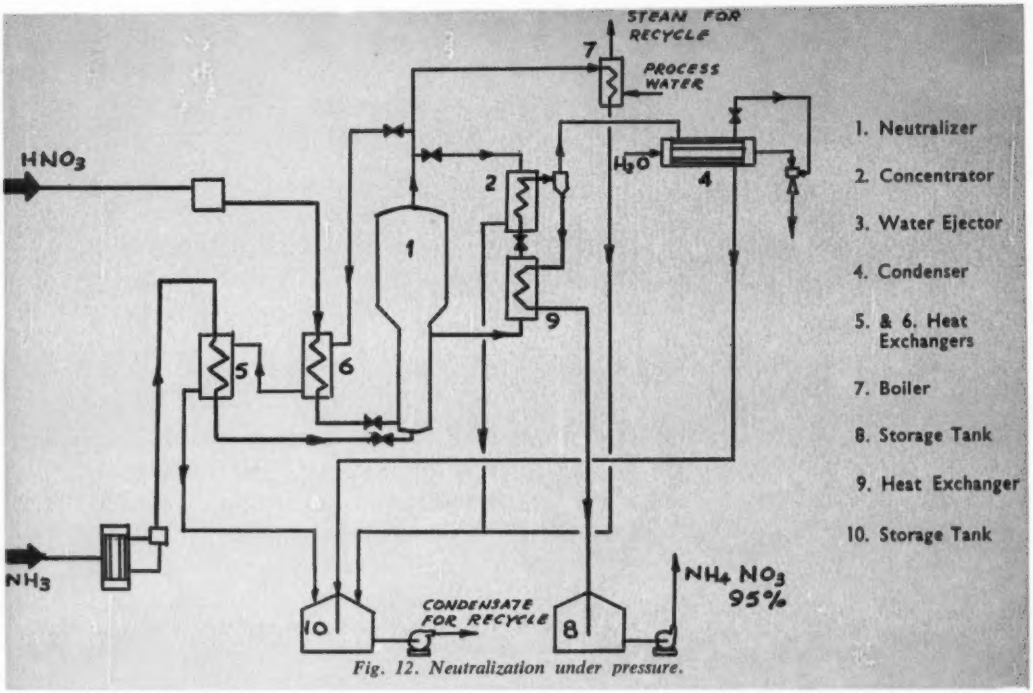


Fig. 12. Neutralization under pressure.

the top of this unit enables steam to be drawn off, leaving the concentrated ammonium nitrate solution. The degree of concentration is determined by the heat supply and the boiling temperature.

Steam released from the neutralizer and concentration unit is fed to a water-cooled, cylindrical condenser, the condensate providing an additional supply for use in pre-heating nitric acid and ammonia. By using in the nitric acid unit this condensate in place of feed water, the small quantities of nitric acid present in the steam can be recovered. Including the recovery resulting from the release of condensates, the overall yield in terms of pure nitrogen employed is 98.7%.

Consumption of steam for concentration of the 83% solution depends on the strength of the nitric acid used. For example, with acid at 54% consumption is approximately 250 kg. of steam per tonne of solution containing 95% ammonium nitrate.

Neutralization under Pressure

When the pressure process is used, neutralization is accomplished at a pressure of between 3.5 and 4 atm., nitric acid and ammonia having been introduced at a slightly higher pressure. After control and correction of its pH, the solution leaving the neutralizer is fed to the vacuum concentrator where heating water is provided by process heat steam from the neutralizer. The vacuum — obtained by water ejection — lowers the boiling point of the solution and provides steam under pressure obtained by the heat of reaction. Ammonia and nitric acid are heated in exchangers using this steam produced. The amount of water evaporated in the concentrators depends on the strength of nitric acid used, and the plant affords surplus steam when using acid with a concentration of more than 50% HNO_3. If the strength of the acid used is above this level, excess of live steam leaving the neutralizer at a pressure of 3 atm. is recovered in a boiler.

Before going to storage, the ammonium nitrate solution is usually reheated in a heat exchanger to avoid any danger of crystallization. The condensate containing small quantities of ammonium nitrate is recycled to the system for recovery. Including the content of ammonium nitrate recovered from the

UTILITY AND RAW MATERIAL REQUIREMENTS

	per tonne of lime ammonium nitrate (20.5% N)		*per tonne of ammonium nitrate (33.5% N)*	
	neutralization at atmospheric pressure	neutralization under pressure	neutralization at atmospheric pressure	neutralization under pressure
Ammonia kg.	128	128	209	209
Nitric acid kg. (100% HNO_3)	470	470	772	772
Diluent k.g.	375	375	—	—
Coating powder kg.	40	40	30	30
Electricity KWH	22	22	30	30
Cooling water m^3	8	8	13	13
Steam at 14 kg./cm^2 kg.	150	—	245	—
Steam produced kg.	—	125	—	—

condensate, the yield from this system in terms of pure nitrogen is 98.7%.

Production of steam depends on the strength of the nitric acid employed and the concentration of the product solution as shown by the following table:—

NITRIC ACID	PRODUCT SOLUTION	STEAM PRODUCTION
strength	*strength*	*tonnes per tonne of ammonia used*
50%	95%	0
54%	95%	1.0
57%	95%	1.5

Control

The production units are remote controlled; the instrument panel, which includes flowmeters, temperature and pressure gauges, and density and pH recorders for controlling the flow of ammonia and nitric acid to the neutralizer is connected to all sections of the installation. In addition, there is warning and safety equipment.

Granulation

The granulation process is based on the use of the latent heat in ammonium nitrate crystallization which promotes the evaporation of any water remaining in the solution. The S.B.A. process does not require any external heat and the end-product is virtually dry.

The ammonium nitrate solution and the diluent are fed to a mixer and thence to storage. This is equipped with a centrifuge which enables part of the solution to be recycled to the neutralizer. The diluent is supplied by way of a conveyor belt equipped with a feeder.

The operation starts in a pre-granulator consisting of a trough equipped with two contra-rotating shafts fitted with blades to ensure a close mixture with the undersize material recovered after screening off the finished granules. During the first stage of granulation only a part of the water content is evaporated and the residual product has the consistency of paste. It is then fed into an air-swept revolving drum where the remaining water is evaporated and the granules form and harden during crystallization.

On leaving this unit, the product is taken to a screening plant where a double action sieve separates the commercial product which is generally confined to granules of between 2 and 4.5 mm. The plant can, however, be adjusted to produce other sizes e.g. 1½ to 2½mm. Granules larger than 4.5mm. are crushed and recycled to the pre-granulator or to the screens. Fines passing through the sieve are recycled to the pre-granulator. The proportion of the material recycled depends on a number of factors, and in particular on the quality of the diluent and the granule size required for the end-product. Generally the volume recycled is between two and three times that of the product flow. Recycling does, however, promote uniformity and constant quality of the end-product.

Before being sent to storage, the granules are coated in a revolving drum, the precoated material being admitted to a feeder. Especially if lime is used as a diluent, stability and storage properties of the product are improved if the temperature is reduced to 10-15°C above the ambient level. This is done in an air swept revolving drum.

From Azote to Onazote

The Manufacture of Expanded Ebonite & its Use as a Thermal and Humidity Insulator

By A. COOPER
F.R.I.C., F.I.R.I., F.P.I., M.Inst.R.

WHEN LAVOISIER furnished a decisive proof of Scheele's earlier discovery that air is a mixture of two gases, he named the "foul air" azote (Greek A — No; zoe — life) still used in France; the name nitrogen (Greek nitron — nitre) was later more widely used throughout the world[1].

In 1909 it was discovered that rubber would absorb nitrogen at high pressures and if the pressure was released faster than the rate of diffusion of the nitrogen from the rubber, the rubber could be expanded to many times its original volume[2]. Later it was found that ebonite (vulcanite or hard rubber) could be expanded in the same way, and by 1920 the product was manufactured and marketed in this country, and it seemed to the inventor at that time that Onazote would be the logical and most appropriate trademark for this product. Ebonite and nitrogen were the basic raw materials, suggesting ebonazote, and hence Onazote.

Nitrogen

In the early days of Onazote manufacture, attempts were made to use air, but it was found unsuitable owing to the oxidising effect on the rubber hydrocarbon, particularly at the high pressures which were generally used in the commercial processes.

It was found essential to use an inert gas and nitrogen became the first choice. To commence with, pure nitrogen was purchased and delivered in high pressure cylinders, but as production of Onazote increased, the daily handling of large numbers of high pressure bottles became quite a problem not to mention the cost involved. Quite clearly it was essential to have a cheap source of nitrogen, and therefore, three possibilities were explored.

1. To acquire a process to produce nitrogen by fractional distillation of liquid air;
2. To burn coal gas in air under carefully controlled conditions, leaving a gas mixture of approximately 90% nitrogen and 10% carbon dioxide.
3. To produce nitrogen from liquid ammonia.

The first of these propositions would entail considerable capital expenditure, the second would make it necessary to remove the carbon dioxide by, for example, reaction with caustic soda, which appeared somewhat cumbersome. It was fortunate that just at that time Imperial Chemical Industries Ltd. had developed a process for production of nitrogen by first cracking the ammonia in an electrically-heated thermostatically-controlled refractory lined

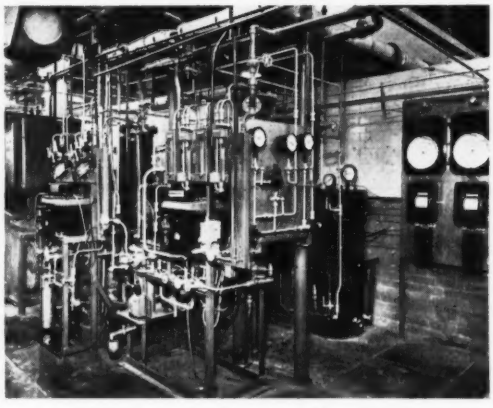


Plate 1. Cracking and burning units.

chamber and then burning this mixture of hydrogen and nitrogen in air under carefully balanced conditions, using up the hydrogen from the mixture by the formation of water

(1) J. R. Partington, "A Textbook of Inorganic Chemistry," 5th Edition, London 1939, 538.

(2) A. Cooper, "The Story of Expanded Rubber," Croydon 1957.

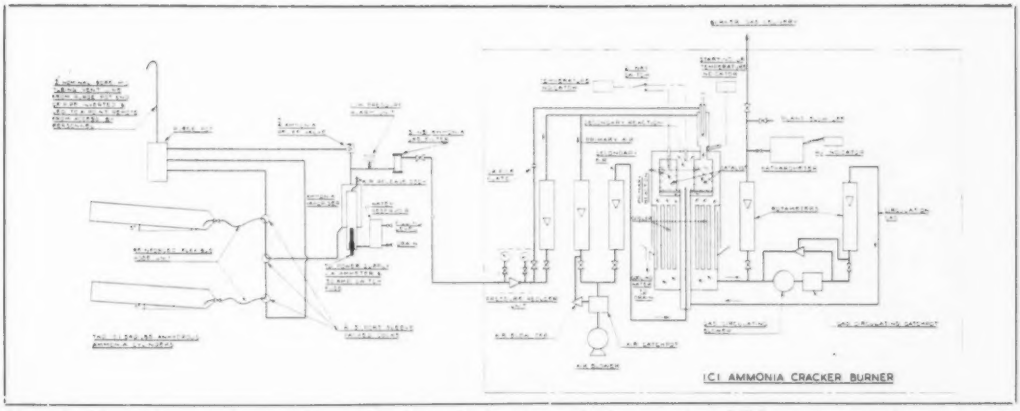


Fig. 13. Flow diagram showing the production of nitrogen rich gases, using I.C.I. equipment, from ammonia.

which could be removed and thus conveniently extracting a considerable " bonus " of nitrogen from the atmosphere to be added to that obtained from the ammonia. This type of plant has been in satisfactory operation producing nitrogen for nearly 20 years. Since then, a new type of nitrogen production unit known as " The Ammonia Cracker Burner " has become available.

In this scheme, as shown in Figure 13, two ammonia cylinders are connected to deliver liquid ammonia to an electrode ammonia vaporiser by way of a three-port cock which selects the cylinder on line. Each cylinder is provided with a three-port cock to enable the ammonia in the connecting hoses to be discharged to atmosphere before the hoses are disconnected. The " purge " ports of the three-port cocks are connected to a purge pot so that any liquid ammonia in the line is not blown directly to atmosphere.

The ammonia electrode vaporiser is a steel vessel with a $\frac{1}{4}$" N.B. branch at the bottom connected to the ammonia cylinders and a $\frac{1}{2}$" N.B. connection at the top leading to the consuming points. A relief valve set to blow at approximately 180 lb./sq. in. (Gauge) is fitted to the vaporiser. The heat required to vaporise the liquid ammonia is provided by steam produced in an electrode boiler fitted to the base of the vaporiser.

A low pressure alarm gauge is connected to the ammonia gas main and is set to sound a warning when the pressure in the ammonia gas main falls to a pre-set figure (generally 35-50 lb./sq. in. (Gauge).

Liquid ammonia flows from the cylinder on line to the vaporiser in which it is maintained automatically at a level which ensures that the amount of liquid vaporised is equivalent to the amount of gaseous ammonia being used. If the gas off-take is reduced the pressure above the liquid in the vaporiser will increase slightly and the level of the liquid ammonia in the vaporiser will be reduced, liquid ammonia flowing back into the cylinder until the amount of heating surface covered by the liquid is sufficient to maintain the reduced ammonia gas rate.

When the ammonia cylinder on line becomes empty the pressure in the system will fall and operate a klaxon.

Ammonia gas at cylinder pressure is supplied to the I.C.I. ammonia cracker-burner which can be operated to produce 5% hydrogen/95% nitrogen wet burner gas at a maximum pressure of 15" w.g. In the cracker-burner a mixture of ammonia gas and air (primary) is passed into the top of a hot (850°-900°C) bed of catalyst where the ammonia is cracked and partially burnt with air. The ratio of the ammonia gas to primary air is such that the hydrogen percentage in the gas at this stage is in excess of the final requirements and the top catalyst temperature is maintained at 850°C. Secondary air is supplied at the bottom of the catalyst container and further combustion of the hydrogen takes place.

The amount of secondary air added is controlled to enable the final hydrogen concentration of the burner gas produced to be maintained at a constant level.

Gas from the catalyst chamber passes through a cooler and then to the points of

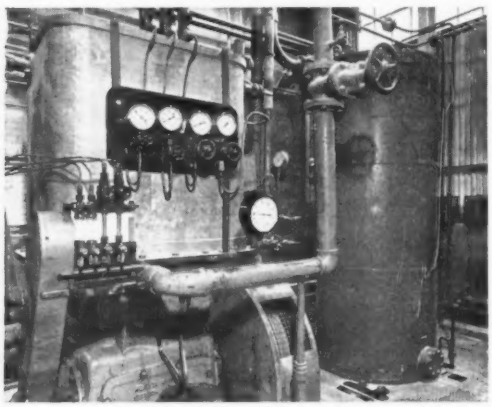


Plate 2. Compression section.

consumption. The hydrogen concentration of the gas produced is continuously measured by arranging for a sample of the gas to pass through an I.C.I. katharometer fitted with a hydrogen indicator.

The temperature of the secondary reaction is controlled at approximately 850°-890°C by drawing cool gas from the system after the external cooler, mixing it with the secondary air stream and re-circulating through the catalyst container.

The burner gas is available at a pressure of 15" w.g. and is saturated with water vapour equivalent to the temperature of the cooling water used (generally equivalent to a dew point of 15°C).

Compressors and driers can be installed to enable dry gas (dew point −40°C) to be available at pressures ranging from 20-2,000 lb./sq. in. (Gauge).

Onazote Manufacture

The first step in Onazote manufacture is to produce an ample and reliable source of 95% pure nitrogen, the balance consisting mainly of hydrogen. The raw material is ammonia which is delivered in 500lb. cylinders. These are sprayed with water to prevent frost formation due to the lowering of the temperature of the cylinders as the liquid ammonia inside vaporises.

The liquid ammonia is cracked in the unit shown in plate 1 on the right-hand side, and the mixture is burnt in the complementary unit shown on the left-hand side of the same plate. Nitrogen is stored in low pressure vessels and gas holders from which it is compressed by multi-stage compressors (plate 2) and pumped into high pressure storage vessels (plate 3). The high pressure autoclaves are charged with the rubber compound, prepared by conventional means, and the nitrogen at pressures up to 5,000 lb./sq. in. is introduced and the material is allowed to remain under pressure until complete saturation of the rubber material is achieved. This is dependent on the temperature and pressure of the autoclave

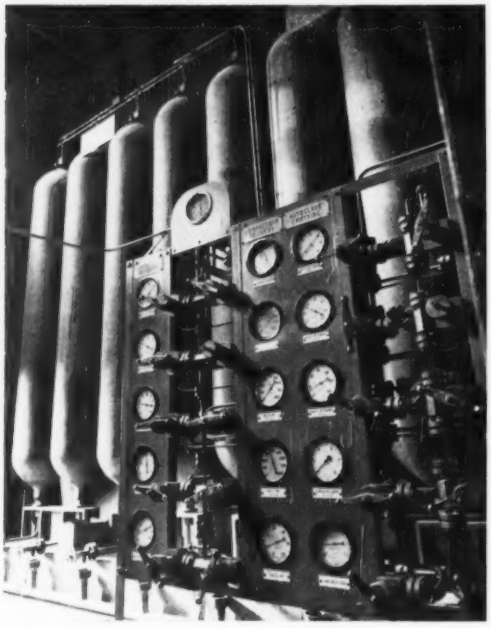


Plate 3. High pressure storage section.

which can be controlled to fairly accurate limits. When saturation is complete, the nitrogen is removed at a rate, faster than its diffusion from the rubber, which expands to a certain extent, within the autoclave, but

more completely during the vulcanising operation in multi-daylight presses (plate 4) where the Onazote boards are fully vulcanised to the ebonite stage ready for use.

Properties of Onazote

Onazote (expanded ebonite) owes its physical properties mainly to its closed cell structure. The photomicrograph (plate 5) shows its uniformity, the main cell wall thickness in Onazote of 4lbs. per cu. ft. density is 0.12mm., the mean cell diameter is ½mm. and there are approximately 20,000 cells per cu.cm. of material.

The general physical properties of Onazote are shown in Table 1, but undoubtedly the two most outstanding properties are, firstly its low thermal conductivity, and secondly its low water vapour transmission.

TABLE 1

General Physical Properties of Onazote

Standard density (nominal)	4lb./cu.ft.	64 kilo/cu.m
Thermal conductivity (by National Physical Laboratory)	0.20 B.Th U/sq.ft. hour °F/inch at a mean temp. of 50°F	0.0247 Kilo.cal./m² hour °C/m at a mean temp. of 10°C
Water absorption	1.5% by vol. after six weeks' total immersion	
Water Vapour Transmission (by Printing, Packaging & Allied Trades Research Association) at 100°F (38°C) and 1—90% relative humidity	1.58 grains/sq.ft./24 hr/2 in.	1.1 gm./sq.m/24 hr/51 mm
Coefficient of linear expansion	0.000028 per °F	0.00005 per °C
Maximum recommended temperature	122°F	50°C
Specific heat	0.33 at 73°F	0.33 at 23°C
Compression strength (ultimate breakdown load)	40lb/sq.in.	2.8 kilo/sq.cm
Tensile strength	35 to 45 lb./sq.in.	2.45 to 3.15 kilo/sq.cm
Impact strength	0.1 ft.lb. on ½in. x ½in. unnotched Izod at room temperature	0.135 joule on 12.7mm x 12.7mm unnotched Izod at room temperature
Modulus of elasticity in compression	2500lb./sq.in	170 kilo/sq.cm
Resistance to chemicals	Resistant to all dilute acids and concentrated alkalis, but not to oils and solvents. Will stain all paints containing lead and cadmium	
Odour	Hydrogen sulphide when freshly cut	
Inflammability	Self-extinguishing. Passes B.S.476/1932, classification 3	
Carbon dioxide transmission (by Printing, Packaging & Allied Trades Research Association)	10.1 cu. in./sq. ft./24 hr/in. Hg.	70 c.c./sq.m/24 hr/mm Hg.

The thermal conductivity at a mean temperature of 50°F determined by the B.S.874 method is only 0.20 B.t.u. in. per sq. ft. hour °F. This K-value is directly proportional to the mean temperature of the test as shown in Table 2.

TABLE 2

Thermal Conductivity of Onazote at various mean temperatures

Tests carried out by the National Physical Laboratory, Teddington.

Density lb./ft.³	*Mean Temperature Hot Face*	*Cold Face*	*cal. cm. cm.²s. deg.C*	*B.t.u. in ft.²h deg.F.*
4	20°C. (68°F.)	0°C. (32°F.)	0.000068	0.20
4½	20°C. (68°F.)	−78°C. (−108°F.)	0.000062	0.18
4½	20°C. (68°F.)	−195°C. (−319°F.)	0.000048	0.14

The water vapour transmission at 38°C and a humidity gradient of 1-90% R.H. determined by a modified B.S.1133 method is only

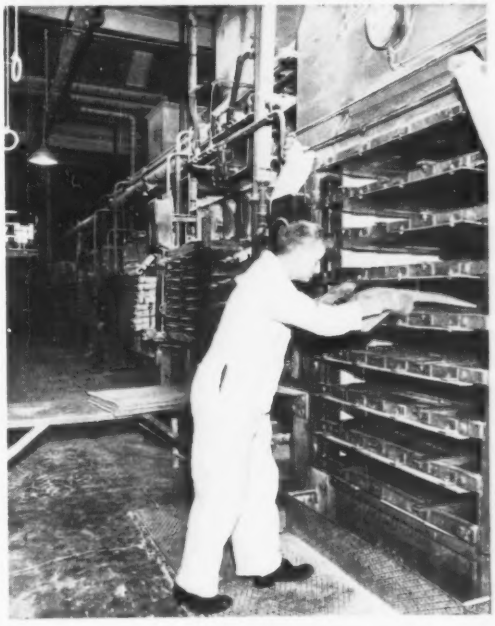


Plate 4. Vulcanisation.

1.1 gms. per M² per 24 hours for a thickness of 51mm. (two inches) which is the same as that for a 1/10 inch pin-hole free layer of bitumen.

No special selection of sample is necessary, as unlike some other insulants this low transmission is consistent throughout the material. Onazote is not a product made from

sintered particles but has structural homogeneity.

It has been shown [3] that low temperatures down to approximately −200°C do not affect Onazote adversely, and for this reason it has become a useful material for really efficient

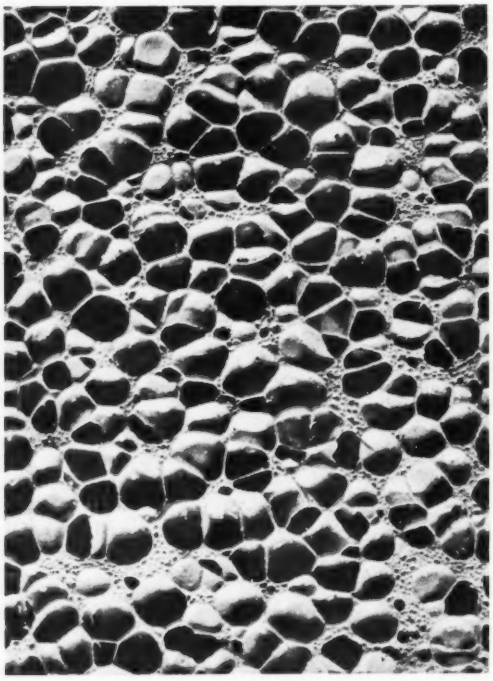


Plate 5. Photomicrograph of Onazote.

low temperature thermal insulation and for the transportation, storage and discharge of liquid gases and ammonia.

In the vast range of chemical applications in fertilizer manufacture and industrial processes, the storage of liquid ammonia is an important consideration. Owing to the low thermal conductivity and other high duty physical properties, Onazote is extensively used for the thermal insulation of liquid ammonia storage vessels.

The ammonia storage vessel at the Flixborough factory of Nitrogen Fertilizer Ltd. is insulated with Onazote. The ammonia used for ammonium sulphate production is obtained from a synthetic ammonia plant as gaseous ammonia at 0°F and 15lb./sq. in. pressure (Gauge) but facilities are available whereby when need arises part of this ammonia can be compressed and stored as a liquid at the same temperature and pressure. The vessel for this storage consists of a 20ft. diameter mild steel sphere lagged with 7″ Onazote insulation. The capacity of the sphere is 80 tons of liquid ammonia at 0°F and 15lb./sq. in. pressure (Gauge).

An even larger vessel for the storage of 2,000 tons of liquid ammonia is shown in plate 6. This is 60ft. in diameter, operating at 32°F and a pressure of 87lb./sq. in. insulated with 3″ Onazote in two layers of 1½″ applied with hot bitumen and finished with galvanised wire mesh, glass scrim fabric and plastic bitumen. It is finally painted with two coats of

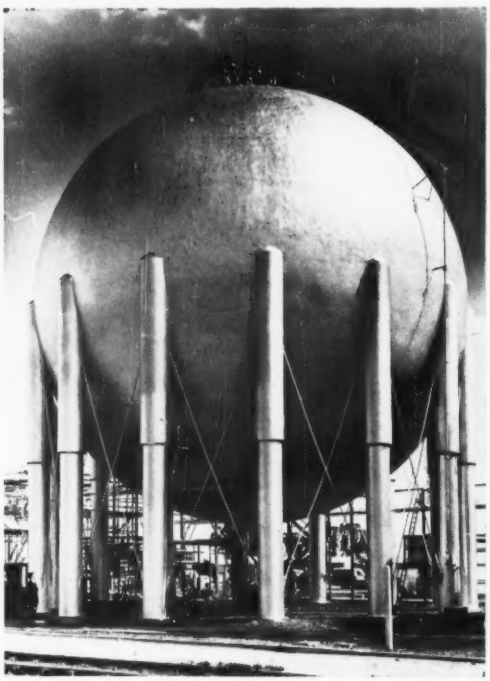


Plate 6. Ammonia storage sphere insulated by Onazote Ltd. at the recently completed ammonium nitrate plant at Stanford-le-Hope for Fisons Ltd.

aluminium paint. The pipelines running down the side of the sphere are also insulated with Onazote and finished with aluminium cladding. The work was carried out by Onazote Insulation Co. Ltd., for Fison's Ltd., at their

(3) A. Cooper, "Low Temperature Properties of Expanded Ebonite." 10th Refrigeration Congress, Copenhagen 1959, 2-5.

Stanford-le-Hope factory. This sphere is believed to be the largest insulated storage vessel of its type in the world.

Ammonia is playing an increasing part in the chemical industry, and although the major outlet is in the manufacture of fertilizers, liquid ammonia is in turn used as a raw material in the manufacture of Onazote, which represents a production cycle which may well be termed the "Onazote cycle."

USE OF WASTE SLURRY IN LIME AMMONIUM NITRATE

AT THE Dneprodgerzhinski Nitrogen Fertilizer Works in the U.S.S.R. waste slurry from ammonium nitrate manufacture is now being used in the production of granulated lime ammonium nitrate. Previously, substantial quantities of waste slurry were being led to waste in the Dnepr river. The slurry contains a fine white powder consisting of calcium and magnesium carbonates (31.9% CaO, 16.1% MgO), 5-6% ammonia and nitrate nitrogen and approximately 2.5% manganese.

Research into methods of incorporating this slurry with ammonium nitrate in the melting and granulating stage started in 1954. It has been found that a 4 : 1 ratio of ammonium nitrate and slurry yields a granulated lime ammonium nitrate containing approximately 28% nitrogen, 8% calcium carbonate, 4% magnesium carbonate and approximately 1% manganese. Half the slurry used is added to the melt, the other half being used for powdering the granules. The product is only slightly hygroscopic and is claimed to be non-caking.

Field trials carried out between 1955 and 1957 with maize and sugar beet showed this grade lime ammonium nitrate to be superior in similar conditions to straight ammonium nitrate.

MAIZE

	1955		1956		1957	
	Cobs 100 kg/ha	*Increase %*	*Cobs 100 kg/ha*	*Increase %*	*Cobs 100 kg/ha*	*Increase %*
No fertilizer	41.1	—	88.7	—	18.0	—
Ammonium nitrate ...	50.0	21.6	103.6	16.8	22.0	22.2
Lime ammonium nitrate	52.3	27.2	104.6	17.9	23.9	32.8

In the 1957 crop the average weight of the cob from land treated with ammonium nitrate was 9% higher than from unfertilized ground, whereas with the use of lime ammonium nitrate results were improved by 28%.

SUGAR BEET

	1955		1956		1957	
	Beets 100 kg/ha	*Increase %*	*Beets 100 kg/ha*	*Increase %*	*Beets 100 kg/ha*	*Increase %*
No fertilizer	232	—	380	—	122	—
Ammonium nitrate ...	260	12.1	412	8.5	137	12.3
Lime ammonium nitrate	271	16.8	414	9.0	141	15.6
	% Sugar	*% Increase*	*% Sugar*	*% Increase*	*% Sugar*	*% Increase*
No fertilizer	16.4	—	14.9	—	152	—
Ammonium nitrate ...	16.5	0.6	16.0	7.4	15.9	4.6
Lime ammonium nitrate	17.6	7.3	17.9	20.1	16.0	5.3

Manufacturing costs of the lime ammonium nitrate are 18-20% higher per unit of nitrogen than those of the straight ammonium nitrate. On the other hand the use of slurry increases the volume of fertilizer material produced and despite the lower nitrogen content its quality as a fertilizer is at the same time enhanced.

plant and equipment

THE LINDBERG "HYNI" GENERATOR

AN IMPORTANT EXAMPLE of the range of high purity nitrogen gas generators now available is the "Hyni" generator developed by the Gas Process Division of the Lindberg Engineering Company of Chicago, Illinois, U.S.A. A feature of this generator is the use of a synthetic zeolite molecular sieve adsorbent for feed gas purification.

The generator operates on the principle of burning a hydrocarbon fuel such as natural gas, methane or propane, in a catalytic combustion chamber to obtain complete reaction with the minimum residual oxygen, oxides of nitrogen and other impurities. Carbon dioxide, water vapour, sulphur dioxide or hydrogen sulphide and traces of nitrogen oxides are simultaneously removed by a molecular sieve. Once the generator is started the operation is automatic and continuous.

Combustion

Fuel gas and air are drawn through visual flowmeters into a combustion controller consisting of a carburettor and a mixing pump. Once the desired air/gas ratio is set by micrometer adjustment, the carburettor maintains this setting automatically. The mixing pump delivers air and gas pre-mixed at the selected ratio to a compressor. Automatic compensation is provided for variations of gas inlet pressure, in atmospheric pressure and in the required combustion feed.

A constant outlet pressure of 1lb. per sq. inch is maintained by the use of a positive displacement compressor equipped with an automatic pressure regulator. The built-in pressure regulator by-passes the unused volume within the compressor, thereby maintaining an unvarying pressure of the mixture delivered to the burner.

The air/gas mixture passes through a lighting torch and a column control valve to a refractory screen burner in the combustion chamber where the presence of a catalyst promotes the complete dissociation of the hydrocarbons to carbon dioxide, carbon monoxide, hydrogen, water vapour and nitrogen. Automatic compensation to offset changes

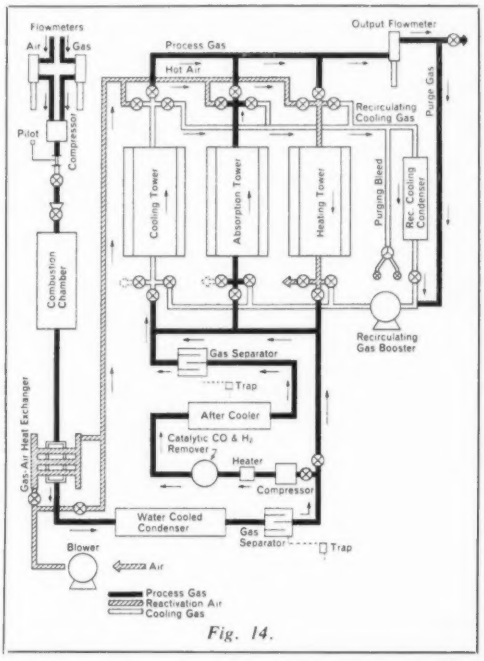


Fig. 14.

in fuel analysis is achieved by a controlling analyzer recording the quantity of oxygen present. If the residual oxygen varies from the content required in the end-product, gas is added or subtracted from the air/gas ratio by a pneumatic proportioning valve.

Heat Exchange and Cooling

The hot products of the combustion chamber pass through a heat exchanger which

heats air, used in another section of the unit for reactivation of absorption material, to a temperature of 600°F. Before entering the heat exchanger, the air is pre-heated in the outer casing of the combustion chamber.

On leaving the heat exchanger the gases pass through a water-cooled surface condenser to remove excess water vapour, and thence to a gas cooler. In this unit moisture is removed by chilling the gases to approximately 50°F.

Catalytic Conversion

When it is necessary that the hydrogen and carbon monoxide contents of the product gas should each be less than 0.5%, a catalytic converter is incorporated in the system. This is an insulated chamber containing a noble metal catalyst—usually platinum or palladium. If a compressor is not used in conjunction with the converter, an external source of heat is required initially to raise the converter temperature to 300-350°F. Once in operation the conversion reaction generates enough heat to be self-sustaining. If a compressor is installed the heat of compression can be utilized to start the conversion reaction.

The use of a catalytic converter totally removes any hydrogen in the gas and reduces its carbon monoxide content to less than 1 p.p.m. The resultant carbon dioxide is removed by the molecular sieve adsorbent in the next stage of the process.

Absorption

Three identical absorption towers are used with the Lindberg process. These are interconnected with valves to permit their consecutive use in the absorption cycle and are controlled by a master timer so that the switch-over from one tower to another is practically instantaneous and there is no interruption in output or change in composition of the product gas. An equal quantity of molecular sieve adsorbent is contained in each of the three towers to remove carbon dioxide and remaining impurities such as sulphur or hydrogen sulphide.

The partially dried gas is selectively fed into the absorption tower in operation. The balance of moisture and carbon dioxide is stripped off and the product gas is piped out for use or storage. The towers are reactivated by heated air, the carbon dioxide laden air being vented.

Zeolites

The synthetic zeolites employed in the molecular sieve adsorbents are composed of soda, lime, alumina and silica and are manufactured by the Linde Co. Division of the Union Carbide and Chemical Corporation. The atoms of sodium or calcium, and silicon, aluminium and oxygen are arranged in a crystalline structure containing a large number of small pores leading to internal cavities and of precisely uniform size. When activated with hot air these cavities adsorb molecules of carbon dioxide, sulphurous impurities, oxides of nitrogen and water vapour.

Cooling

The cooling cycle employed with the Lindberg generator is a closed system with a small quantity of the product gas being recirculated through a booster, cooling tower and the water-cooled surface condenser. The system is valved to ensure a controlled intake of purified product gas, a like quantity being simultaneously vented.

Safety Factors

A manual reset safety valve stops the generator if the feed gas pressure falls below the safety level. An alarm and signal lights indicate when this happens.

An automatic fire safety device is installed between the gas mixing compressor and the combustion chamber. In the event of a back-fire this valve closes, sounds an alarm and shuts off the gas mixing compressor. Protection against flame failure is provided by low and high contacts fitted to the oxygen analyzer, an alarm being sounded when the oxygen content of the combustion feed gas exceeds the safe limit. The only cause for flame failure, once the generator is at operating temperature, would be a failure in the fuel or power supply. Another piece of safety equipment installed with the generator is a flow switch on the water cooling system, which sounds an alarm when the flow drops below the minimum safety requirement.

Products

The Lindberg generator may be operated to produce an atmosphere totally free from

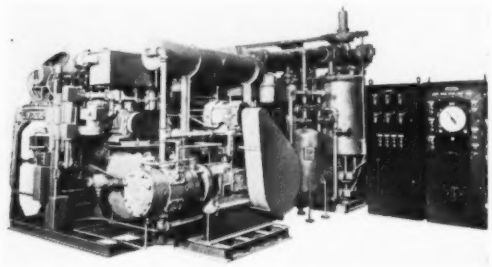
oxygen with a content of combustibles (carbon monoxide and hydrogen) from 0% up to 24%. The following analysis is an example :—

Oxygen	0.00%
Carbon dioxide	0.01%
Hydrocarbons	0.50%
Water vapour	less than 80° F dew point
Hydrogen	13.00%
Carbon monoxide	11.00%
Sulphur	0.00%
Oxides of nitrogen	0.00%
NITROGEN plus argon trace	balance

If total absence of these combustibles is required in an atmosphere free of oxygen, the catalytic converter must be employed. The following product can then be obtained :—

Oxygen	0.00%
Carbon dioxide	0.01%
Hydrocarbons	0.00%
Water vapour	less than 80° F dew point (7.p.p.m.)
Hydrogen	0.50%
Carbon monoxide	0.50%
Sulphur	0.00%
Oxides of nitrogen	0.00%
NITROGEN plus argon trace	balance

It is claimed that the Lindberg generator can produce high purity nitrogen for U.S. cents 17 to 20 cents per 1,000 cubic feet. This costing is based on the use of fuel gas at U.S. cents 60 per 1,000,000 BTU electricity at 1 cent per KWH and cooling water at 5 cents per 1,000 gallons. It does not take into account maintenance or amortization. It is, however, claimed that no corrosion problems are encountered



A "Hyni" nitrogen generator with a capacity of 200 cubic feet per hour.

with the generator and that there is no loss of adsorbent.

Applications

The applications of high purity gaseous nitrogen are of steadily increasing variety and importance. In metallurgy it serves as the carrier atmosphere in bright hardening of steel obviating carburization and decarburization, in annealing and normalizing, in brazing copper and silver, in sintering of powder metals, and in gas carburizing and carbonitriding. In the chemical industry high purity nitrogen is used as a blanketing atmosphere to prevent oxidation and as a purging atmosphere to prevent explosion and to remove toxic gases. In the food processing industry it is used as an inert atmosphere whenever this is required to retain the taste, smell and appearance of a product and as an atmosphere for the preservation of qualities otherwise lost through contamination, oxidation or bacterial action.

Throughout the world the consumption of high purity nitrogen gas is growing steadily and now amounts to some 20 billion cubic feet a year. In the United States alone demand rose from 6.6 billion cubic feet in 1958 to 13.5 billion cubic feet in 1959, a rate of expansion that may well be maintained for several years to come.

AMMONIA LIQUOR CONCENTRATION PLANT FOR THE SCOTTISH GAS BOARD

THE SCOTTISH GAS BOARD'S total gasification plant now under construction at Westfield, Fife, is to be equipped with an ammonia liquor concentration unit supplied by Newton Chambers & Co. Ltd. of Thorncliffe, Sheffield. Crude ammonia liquor obtained as a by-product of the Lurgi gasification process will contain approximately 2.5% ammonia, practically all of which is in the "free" state as ammonium sulphide and ammonium carbonate with only traces of thiosulphate, thiocyanate and chloride. Produced at a rate of 32,000 gallons a day, the crude liquor will be concentrated to a strength of 24% ammonia.

After complete separation of tar, the crude liquor is pre-heated to about 90°C by heat exchange with still vapours. A photo-electric cell is incorporated in the crude liquor supply which, in the event of the liquor containing tar, will automatically shut down the plant to prevent the introduction of tar. The crude liquor is then passed into the decarbonator where steam, supplied at a rate of

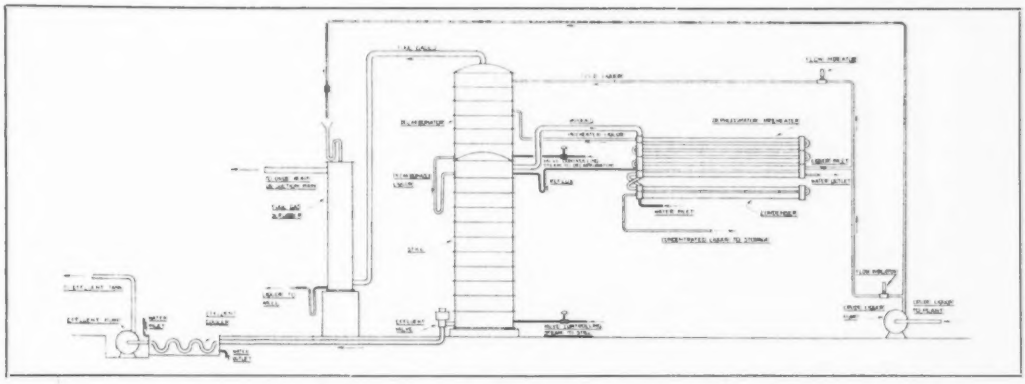


Fig. 15. Flow diagram of a crude liquor concentration plant.

about 50lbs. per 100 gallons of liquor, is used for decarbonisation and desulphurisation. A small quantity of cold crude liquor is fed into the decarbonator to wash selectively the foul gases so that the ammonia loss at this process step is minimised. Any residual ammonia in the foul gases is finally removed by washing with cold liquor in a foul gas scrubber. On leaving this scrubber, the foul gases, consisting principally of carbon dioxide and hydrogen sulphide, are then discharged and passed to a gaseous effluent treatment plant.

The decarbonated liquor flows by gravity to the still where its free ammonia content is removed by steam supplied at a rate of about 150lbs. per 100 gallons of liquor. The vapours leaving the still head, and consisting substantially of ammonia and steam but with traces of carbon dioxide and hydrogen sulphide, are first passed through a heat exchanger and then cooled with water to obtain the concentrated liquor which then passes to storage. The effluent liquor, containing less than 0.025% free ammonia, is finally cooled in a plate type cooler and discharged to drain. Control of the plant is completely automatic and chemical supervision staff are the only labour required.

current events

ALGERIA

Nitrogen Production Foreseen

Plans for the first nitrogen works to be built in Algeria are being drawn up and it is hoped that production will start in 1962. The Soc. Algerienne de l'Azote "Azotol," a partly-owned subsidiary of the Cie. Algerienne de Petrochemie, will operate the plant which is to be built near Bône and which will have an annual capacity of 60,000 tonnes N based on the use of natural gas. The ammonia produced will be used in the manufacture of ammonium sulphate and urea. A pipeline is shortly to be laid to bring natural gas from the Hassai R'Mel deposit and it is envisaged that some 3,000 million cubic metres a year will be used in the manufacture of synthetic ammonia, a number of petroleum products and for electrolysis of chlorine. Hassai R'Mel gas at its present price of 1.30 old francs per thermal unit is among the cheapest in the world.

Nitrogen from Solar Radiation

Considerable interest is being shown in the possibility of establishing factories in the Atlas Mountains or in the Northern fringe of the Sahara to use reactions brought about

by the ultraviolet radiation of sunlight to produce nitric acid. Experiments now being conducted in Algeria by the Centre National pour la Recherche Scientifique in conjunction with Algiers University involve the use of a paraboloid aluminium mirror, 27ft. in diameter, which can follow the sun. Similar experiments being carried out at the Fort Mont Louis laboratory near Perpignan in France use flat directing mirrors to reflect the sun's radiation on to a fixed focussing mirror. Both installations can achieve temperatures of the order of 5,000°F for the production of nitrous oxides, the first step in the manufacture of nitric acid. Although these experimental installations were built for research at a cost which would render their use in commercial operation prohibitive, it is believed that equipment could be designed to yield nitric acid at a price which would make it possible to manufacture nitrogen fertilizers at a cost below that of imported materials.

BULGARIA

Second Nitrogen Fertilizer Works Planned

Concurrent with the expansion of the "Stalin" nitrogen fertilizer works at Dimitrovgrad, a second plant is to be built in Bulgaria at Stara Zagora. The new works, to be built with technical assistance from the U.S.S.R., is due to come into operation in 1963 with an annual capacity of 300,000 tonnes of ammonium nitrate. Ammonia production will be based on the use of lignite from the East Maritsa Basin. It is intended that subsequent extensions to the works will raise the ammonium nitrate capacity to 500,000 tonnes a year by 1966 and include a 20,000 tonnes per year urea plant.

The "Stalin" works at Dimitrovgrad, with a capacity of 40,000 tonnes N based on the use of coal, produce ammonium sulphate, ammonium nitrate and sodium nitrate. Expansion work already in progress will raise the plant capacity to 100,000 tonnes N by 1961 and includes the installation of a urea plant with an annual capacity of 10,000 tonnes.

Bulgaria's nitrogen fertilizer production in 1958/59 amounted to some 25,000 tonnes N, while consumption in the same year was estimated at 47,000 tonnes N—an increase of 18,000 tonnes N over the level in 1957-58. By 1963, however, the extensions to capacity should make Bulgaria independent of supplies imported from the U.S.S.R. and East Germany.

CENTRAL AMERICA

Panama and El Salvador Projects

It has been reported that National Bulk Carriers Inc. are planning an ammonia plant to use waste gases from an oil refinery to be built at Panama. No figure has been given for the capacity of the proposed installation but it is understood that it is intended to ship anhydrous ammonia in large ocean-going vessels to markets in Central America and the Carribean area. This would be the first instance in the history of the Nitrogen Industry of a major operation for shipping ammonia in bulk. The ability to produce and carry ammonia at low cost would place National Bulk Carriers Inc. in a highly competitive position throughout the entire Central American market.

It is hoped that the fertilizer works projected for El Salvador will be among those supplied with ammonia from the Panama plant. An economic study is at present being conducted to investigate the feasibility of this project and a provisional location has been selected near Acajutla in the Gulf of Fonseca. Outline plans provided for a daily capacity of 140 tonnes of anhydrous ammonia to be used in the manufacture of 80 tonnes of urea, 150 tonnes of ammonium sulphate and 100 tonnes of di-ammonium phosphate a day. If, however, the works are supplied with ammonia from Panama, the installations in El Salvador may be confined to the ammonia conversion plants, together with a small phosphoric acid unit and mining facilities.

The El Salvador project was initiated several years ago when it became apparent that increased use of fertilizers, rather than further mechanisation, was necessary to expand the coffee and cotton crops. At present El Salvador imports fertilizers to the value of U.S. $5\frac{1}{2}$ million a year and it is intended that the projected plant would meet virtually all this domestic requirement and at the same time be able to take advantage of demand in neighbouring Central American countries. Preliminary estimates assessed the cost of the

proposed plant at £5½ million, and although finance plans have not been finally decided, it is understood that the Government may provide some of the capital required, while it hopes that both local and foreign investors will also participate. El Salvador has adequate supplies of hydro-electricity, but so far as is known, no exploitable raw materials suitable for use in the plant.

Responsibility for the project has been placed with the Instituto de Fomento de la Produccion, a Government agency, which has commissioned a group of specialised consultants to prepare plans and examine cost estimates and the market potential. It is intended that work, supervised at first by foreign technicians, should start at once if a favourable report is submitted by the consultants. Ultimately, much will depend on whether it is thought that the proposed plant would be capable of producing fertilizers at prices which would be competitive on world markets. The feasibility of including ammonia installations in the works will be influenced by the ability of the proposed Panama plant to supply at an attractive price and by efforts to drastically scale down the capital outlay.

FORMOSA

Law Suit over Nankong Urea Works

A $10.7 million civil law suit has been filed by the Taiwan Fertilizer Co. against Hydrocarbon Research Inc. of New York. The Formosan firm allege that the ammonia plant built for them by Hydrocarbon Research Inc. has failed to operate satisfactorily. The 100 tonne per day synthesis unit was completed in March 1958 at Nankong, seven miles east of Taipei, as part of a $25 million urea fertilizer works financed by the United States Government International Co-operation Administration. The urea installations, with an annual capacity of 84,000 tonnes, were completed 18 months after the ammonia plant.

Hydrocarbon Research Inc. were contracted in 1954 to engineer and supervise construction of the ammonia plant, the Taiwan Fertilizer Co. being responsible for its erection and maintenance and for the provision of personnel. The urea installations were the responsibility of the Vulcan Copper and Supply Co., operating under licence from the Swiss firm Inventa A.G.

The Taiwan Fertilizer Co. maintains that the works have produced less than 3,000 tonnes of urea since coming into operation instead of 128,000 tonnes as planned and that this has been due to failure of the ammonia unit to operate continuously.

Hydrocarbon Research maintain that any failure of the ammonia plant to give satisfactory operation has been due to a number of factors beyond their control, notably lack of experienced maintenance and operating personnel, shortage of electric power supplied from outside sources, and typhoons.

The Taiwan Fertilizer Co. operates five other fertilizer works with a combined production capacity of 79,000 tonnes of calcium cyanamide, 35,000 tonnes of nitrophosphate, 94,000 tonnes of calcium superphosphate and 10,000 tonnes of fused phosphate. Towards the end of 1959 the company obtained a loan of U.S.$200,000 towards the cost of raising their nitrophosphate capacity to 150,000 tonnes a year and tenders are to be invited for procurement of machinery and equipment.

FRANCE

Urea-Formaldehyde Fertilizer

"Azorgon," a urea-formaldehyde fertilizer, is now being manufactured at the Toulouse works of the Office National Industrial de l'Azote (O.N.I.A.). A slow-acting fertilizer, "Azorgon" is primarily intended for horticultural use. Production started in 1959 at a rate of 100 tonnes a month, but this has since been raised to 300 tonnes a month. The urea installations at the Toulouse works employ the Fauser Montecatini process and their capacity is at present at an annual level of 35,000 tonnes.

INDIA

Work Starts on Neyveli Urea Project

Following the award of contracts worth nearly £11 million to Italian and West German firms, work has started on the erection of the Neyveli Fertilizer works in Madras State, which will include the world's largest urea plant, an

installation with a capacity of 152,000 tonnes a year. The State-owned works will use some 35 million tonnes of lignite a year from adjacent mines for use in the production of ammonia, urea, carbonized briquettes, thermal power and a number of by-products including tar, phenol and gasoline. An additonal programme envisages the use of China clay, recovered from lignite, for the manufacture of refractory brick, sanitary and domestic ware and electric insulators.

Fauser-Montecatini processes will be employed in both the ammonia synthesis and urea installations and Soc. Montecatini are designing and engineering these units for Soc. Ansaldo, the principal contractors. A total recycle system will be used in the urea plant. Equipment for drying and treating lignite, its gasification and purification are being supplied by Pintsch Bamag A.G. of Butzbach, West Germany, while another West German firm, Lindes Eismaschinen A.G. are supplying the air fractionation and synthesis gas mixture equipment. The urea installations are due for completion in the latter part of 1962 and are expected to come into operation early in 1963.

MALAYA

Fertilizer Project

Plans are being drawn up by the Standard Vacuum Oil Co. of New York and the Wah Chang Corp. of New York for the erection of a nitrogen fertilizer works in Malaya. Forming part of a $M.920 million investment programme in Malaya by the Standard Vacuum Oil Co., the fertilizer plant would use raw materials supplied from an oil refinery which Standard Vacuum will build to meet its requirements for principal petroleum products in the Malayan peninsula.

No firm decision has yet been taken on the location, capacity and end-products of the proposed plant, but it is intended that it should be capable of meeting Malaya's nitrogen fertilizer demand. Consumption is at present at a level of 20,000 tonnes N, the bulk of which is in the form of ammonium sulphate. Principal suppliers in recent years have been the United Kingdom and Belgium.

SPAIN

Credits for New Plants

Two Spanish firms, Abonos de Sevilla S.A. and Refineria de Petroleos de Escombreras S.A. (REPESA), have been granted credits totalling U.S. $17.6 million by the United States Export-Import Bank to assist in the construction of nitrogen fertilizer plants.

Abonos de Sevilla S.A., an equally owned subsidiary of Union Espanola de Explosivos and Soc. Iberica del Nitrogeno (SIN), is building a U.S. $27 million fertilizer works near Sevilla. Due for completion in 1963, the new works will have an annual capacity of 273,000 tonnes of compound fertilizers containing 25,000 tonnes N, 30,000 tonnes P_2O_5 and 25,000 tonnes K_2O. The nitrogen installations, for which the principal contractor is the Lummus Co. of New York, will be based on the use of fuel oil and production will be largely in the form of ammonium nitrate.

REPESA, jointly owned by the Instituto Nacional de Industria (INI), Cia. Espanola de Petroleos S.A. and the Caltex Oil Products Co. Ltd. of New York, will build a plant at Cartagena with an annual capacity of 90,000 tonnes N based on the use of refinery gases. Ammonia will be used in the manufacture of 73,000 tonnes of urea and 200,000 tonnes of ammonium sulphate a year. Due for completion in 1962, this will be the second largest nitrogen works in Spain.

In 1958/59 nitrogen fertilizer production in Spain amounted to 60,000 tonnes N, two-thirds of which was in the form of ammonium sulphate. In the same year consumption was 260,000 tonnes N—25% more than in 1957/58. By 1963/64, however, it is expected that domestic nitrogen capacity will exceed 400,000 tonnes N and that dependence on imported supplies will be substantially reduced.

Statistical Appendix

United States

Production

Short Tons

		Anhydrous Ammonia Synthetic	Ammonium Nitrate (100% NH_4NO_3) Total	Ammonium Nitrate (100% NH_4NO_3) Fertilizer	Ammonium Sulphate Synthetic	Ammonium Sulphate By-product	Nitric Acid (100% HNO_3)	Nitrogen Solutions (100% N)*
1957	**TOTAL**	**3,734,213**	**2,586,007**	**2,338,576**	**1,039,822**	**908,903**	**2,843,488**	**563,423**
1958	**TOTAL**	**3,831,420**	**2,524,057**	**2,272,905**	**1,097,750**	**640,852**	**2,601,915**	**631,903**
1959	**TOTAL**	**4,504,317**	**2,864,897**	**2,582,938**	**1,095,381**	**678,441**	**3,073,852**	**829,159**
	July	294,664	176,748	162,311	85,776	48,019	191,792	30,283
	August	280,581	184,742	166,244	84,231	50,114	196,916	40,161
	September	304,753	208,760	186,150	92,583	51,526	223,748	56,088
	October	325,987	233,259	208,362	84,475	58,455	254,529	49,256
	November	333,860	237,067	214,407	96,327	61,564	258,135	54,078
	December	324,626	228,343	208,059	89,084	64,770	244,816	66,553
1959	January	333,805	227,887	207,464	88,531	63,604	240,780	52,119
	February	326,454	216,428	193,386	87,075	63,817	240,969	56,768
	March	384,128	249,724	222,768	94,940	73,774	267,215	87,249
	April	400,156	243,704	215,618	97,201	73,020	268,141	109,235
	May	413,134	244,336	219,238	88,795	71,568	261,689	95,420
	June	386,755	217,172	194,878	81,811	69,955	233,005	52,757
	July	366,509	216,296	194,531	72,926	24,764	233,412	40,486
	August	342,634	230,166	210,840	92,162	14,559	241,848	54,487
	September	358,981	245,478	221,103	96,087	—	261,343	68,248
	October	389,956	249,279	228,203	93,451	17,212	268,720	64,531
	November	382,072	253,541	230,551	94,454	47,746	268,462	64,742
	December	419,733	270,886	244,358	107,948	68,422	288,268	83,117

* Including combinations with urea.

Exports—Fertilizer Year 1958-59

Short Tons

Ammonium Sulphate

Canada	7,378
Mexico	23,292
British Honduras	888
Salvador	2,281
Honduras	200
Costa Rica	835
Cuba	52,213
Dominican Republic	11,960
Venezuela	6,977
British Guiana	3,050
Peru	45,686
Brazil	36,967
Ireland	3,365
Spain	155,712
Indonesia	220
Korean Republic	30,856
Belgian Congo	2,089
Mozambique	700
Union of South Africa	18,184
Argentina	5,676
Others	1,598
Total	**411,077**

Ammonium Nitrate

Mexico	37,259
Cuba	1,113
Philippines Republic	665
Honduras	100
Peru	4,250
Union of South Africa	4,600
Colombia	100
Greece	18,318
Liberia	175
Costa Rica	200
Ecuador	530
Korean Republic	19,841
Chile	1,750
Arabia	400
Iceland	3,196
Others	336
Total	**92,833**

Ammonium Phosphate

Canada	11,910
Mexico	15,453
Colombia	100
Venezuela	1,703
Greece	1,102
Cuba	2,120
Philippines Republic	5,386
Ecuador	335
Bolivia	300
Uruguay	227
Argentina	1,102
Nicaragua	1,484
Dominican Republic	180
Taiwan	11,762
Costa Rica	1,879
Brazil	199
Union of South Africa	118
Guatemala	250
Salvador	500
Honduras	250
Thailand	3,186
India	759
Others	401
Total	**60,706**

Urea

Canada	4,134
Mexico	18,012
Guatemala	1,451
Nicaragua	267
Cuba	1,249
Jamaica	1,231
Ecuador	1,998
Philippines Republic	2,460
Costa Rica	4,726
Dominican Republic	598
Colombia	8,720
France	406
Korean Republic	31,885
Haiti	280
Honduras	6,525
Peru	230
Salvador	255
Venezuela	192
Panama	946
United Kingdom	448
Others	112
Total	**86,125**

Other Nitrogenous Fertilizers

Canada	20,856
Mexico	736
Cuba	14,200
Peru	110
Brazil	445
Korean Republic	127
Denmark	275
Others	249
Total	**36,888**

Belgium

Production

Tonnes

		Synthetic Ammonia		By-product Ammonium Sulphate	Fixed Nitrogen for technical use	Compound Fertilizers	
		Total N content	Fertilizer N content	N content	tons product	tons product	N content
1958	1st quarter	64,691	58,723	4,255	1,401	66,461	6,768
	2nd quarter	68,079	63,747	4,871	1,734	56,199	6,236
	3rd quarter	69,684	50,465	4,572	1,545	46,726	4,171
	4th quarter	72,469	66,189	4,543	1,764	72,292	5,521
1958	**TOTAL**	**274,923**	**239,124**	**18,241**	**6,444**	**241,678**	**22,696**
1959	1st quarter	75,593	68,812	3,688	1,644	70,866	5,305
	2nd quarter	78,241	71,400	4,104	1,367	48,832	5,415
	3rd quarter	70,223	61,282	4,081	3,294	47,862	4,812
	4th quarter	79,579	69,626	4,349	3,247	70,021	5,963
1959	**TOTAL**	**303,636**	**271,120**	**16,222**	**9,552**	**237,581**	**21,495**

Exports – First Half of Fertilizer Year 1959-60

Ammonium Nitrate

United Kingdom	8,659
Portugal	1,575
Uruguay	150
China	29,957
New Zealand	405
Belgian Congo	81
Brazil	420
Australia	102
Netherlands	40
Nigeria	18
Peru	250
Saudi Arabia	395
Egypt	7,100
Union of South Africa	544
Trinidad & Tobago	108
Total	**49,804**

Ammonium Sulphate*

United Kingdom	64,529
Ireland	3,186
Portugal	12,354
Greece	10,007
Belgian Congo	1,430
Canary Islands	4,950
Kenya & Uganda	126
Spain	32,550
Dominica	1,801
China	173,760
France	5,886
Brazil	11,894
New Zealand	254
Puerto Rico	10,408
Argentina	1,692
Mexico	9,958
Venezuela	10,264
Salvador	1,842
Peru	6,611
Iran	2,000
Philippines Republic	2,000
India	12,714
Netherlands	505
Total	**380,720**

* Includes Ammonium Sulphate Nitrate.

Calcium Cyanamide

Netherlands	3,093
France	1,080
Belgian Congo	175
Others	101
Total	**4,449**

Ammonium Phosphate

Netherlands	4,000
United Kingdom	5,617
Greece	17,371
Mexico	1,000
Uruguay	695
Iran	1,000
Indonesia	5,449
Others	3,899
Total	**39,031**

United Kingdom

Fertilizer Exports

Ammonium Nitrate

	Fertilizer Year 58/59	First Half Fertilizer Year 59/60
Nigeria	1	—
Australia	72	25
New Zealand	72	53
Irish Republic	28	—
Turkey	592	—
Canary Is.	10	—
Israel	393	—
Brazil	225	—
Ceylon	10	—
U. of S. Africa	—	40
Others	—	14
Total	**1,403**	**132**

Ammonium Sulphate

	Fertilizer Year 58/59	First Half Fertilizer Year 59/60
Channel Is.	640	—
Malta & Gaza	603	500
Cyprus	2,192	—
Ghana	64	—
Nigeria	519	194
Rhodesia & Nyasaland	3,970	1,316
Tanganyika	365	520
Uganda	—	858
Kenya	1,362	504
Mauritius	25,887	21,780
Singapore	8,334	8,105
Fed. of Malaya	27,272	24,711
Ceylon	50,430	61,566
Sarawak	451	222
Hong Kong	148	—
Australia	19,899	50
New Zealand	2,095	1,022
Fiji	6,501	3,476
Canary Is.	—	5,067
Irish Republic	—	2,008
Canada	336	113
Jamaica	4,599	688
Leeward Is.	640	180
Windward Is.	1,040	85
Barbados	10,526	—
Trinidad & Tobago	14,991	1,650
Br. Guiana	6,188	1,901
Br. Honduras	1,000	—
Sweden	120	—
Norway	244	—
Spain	24,697	10,304
Canary Is.	4,871	—
Lebanon	875	2,273
Thailand	1,083	393
Vietnam	8,472	146
N. Borneo	—	—
Others	234	271
Total	**230,648**	**149,903**

Other Nitrogenous Fertilizers

	Fertilizer Year 58/59	First Half Fertilizer Year 59/60
Channel Is.	27	—
Cyprus	26	—
India	99	120
Ceylon	1,149	224
Hong Kong	199	—
Fiji	100	—
Liberia	50	—
Mexico	30	—
Lebanon	97	—
Iran	270	—
Costa Rica	176	—
El Salvador	56	314
Cuba	125	—
U.S.A.	833	100
Irish Republic	—	101
Fed. of Malaya	—	163
Others	94	75
Total	**3,331**	**1,097**

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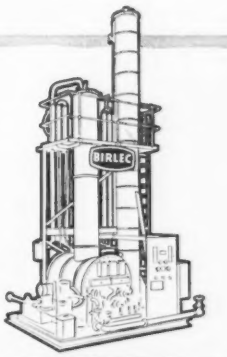

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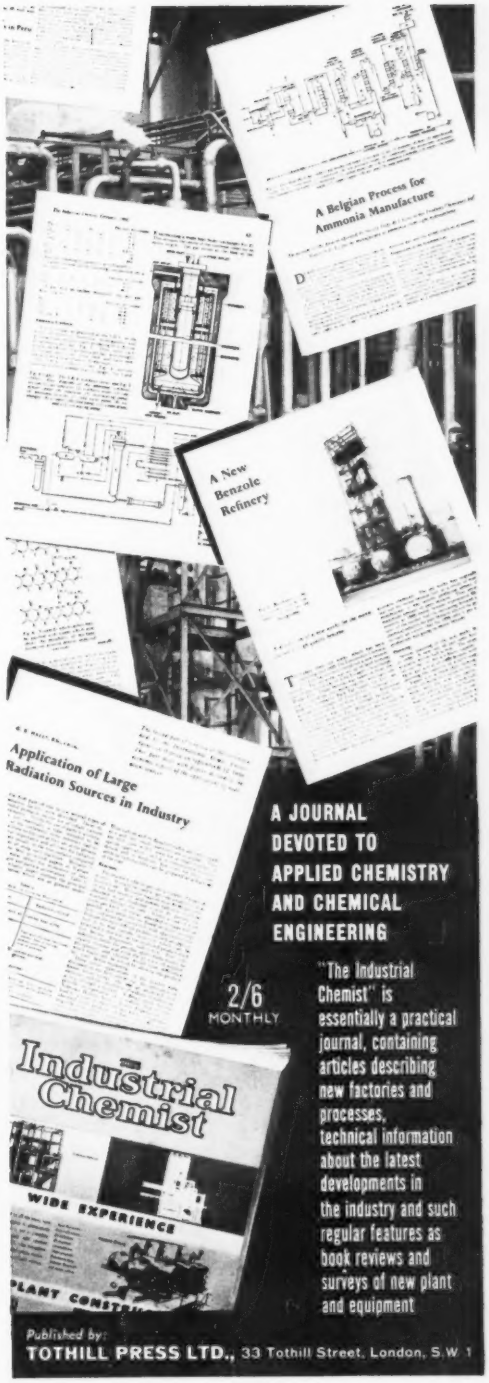
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